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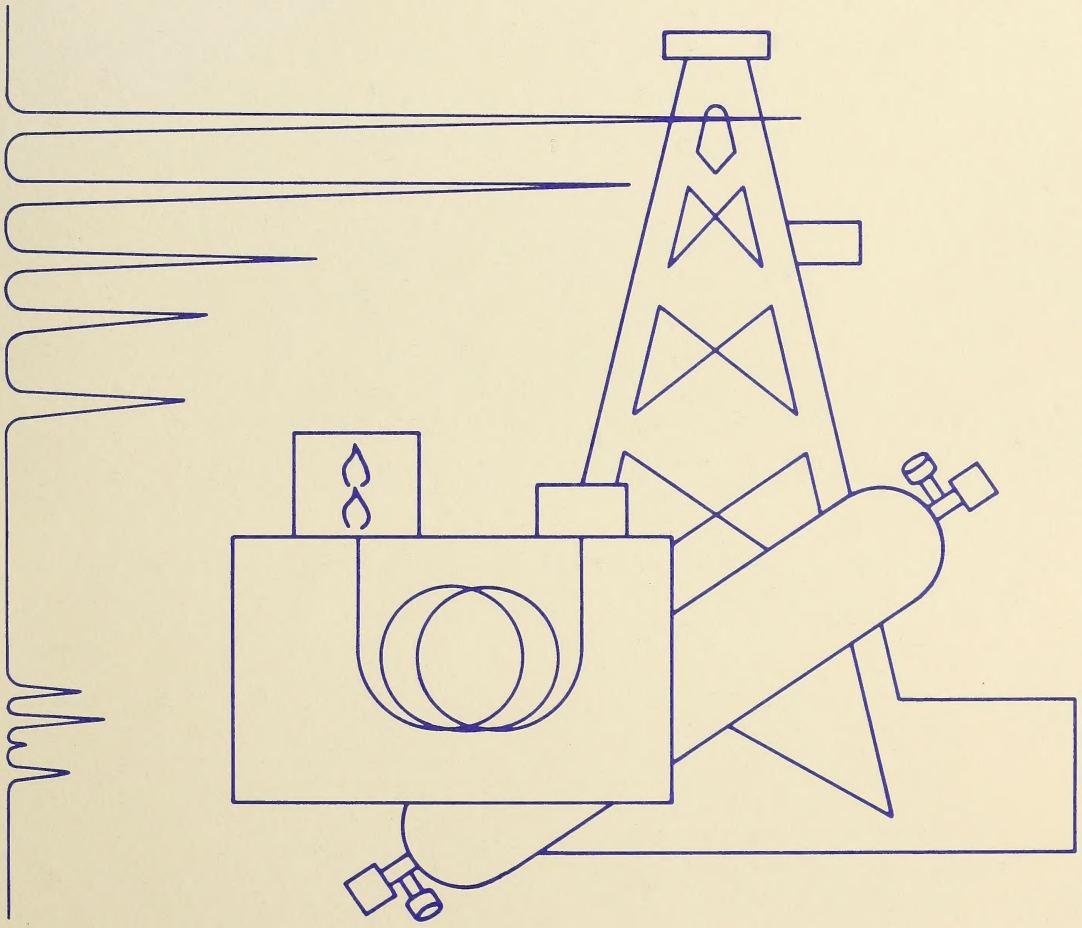
Sulphur Compounds in Natural Gas Study



January 1990

ERCB

Sulphur Compounds in Natural Gas Study

Printed and Published by
Energy Resources Conservation Board,
Calgary, Alberta

ACKNOWLEDGEMENTS

The Board would like to express its appreciation to the following people:

Susan Halla, Chemical Technologist, author of this study.

The Lodgepole Blowout Inquiry Panel for their direction and belief in the importance of this study:

V. Millard
G. J. DeSorcy
N. A. Strom
J. W. Markham
F. A. Herbert
R. S. Weaver

Harry Lillo, Manager of the ERCB's Environment Protection Department, for his continual guidance and support throughout the project.

Harald Thimm for his valuable comments and suggestions on the first draft of this report.

Harvey Halladay of the ERCB's Gas Department for providing the calculations to extrapolate the data from a sample basis to a total gas effluent basis.

Those who reviewed the final draft of the report:

Dr. Graham Gibbs, Occupational Health and Safety
Dr. F. Alex Herbert, Department of Medicine, U of A
Carl Primus, Alberta Health
A. R. Shultz, Alberta Environment
Dr. R. S. Weaver, Alberta Environmental Centre
Dr. J. W. Markham, Department of Community Medicine, U of A
Henry Bertram, Alberta Environmental Centre

Support staff from the ERCB in Drafting, Printing and Administrative Services Departments.

And last but far from least, the staff of the ERCB and Chemical Research Laboratory who provided moral and technical support and endured the various strange odours sulphur compounds emit:

Merl Korchinski
Don Roberts
Irene Zaborski
Kelly Pisiak
Lisa Batke

Special thanks are extended to past employees of the ERCB Chemical Research Laboratory: Ina McDonald and Don Shaw who shared their vast knowledge and experience in high-pressure gas and condensate sampling and analysis; Judy Schafer who typed the draft report on the lab's personal computer.

CONTENTS Page

SUMMARY viii

1 INTRODUCTION 1

2 THEORY 3
2.1 General Chromatography 3
2.2 Flame Photometric Detector 4
2.3 Flame Ionization Detector 6

3 QUANTITATIVE GAS AND QUALITATIVE CONDENSATE ANALYSIS (1984-1986) 7
3.1 Development (1984-1986) 7
3.2 Methodology (1984-1986) 11
3.2.1 Analytical System 11
3.2.2 Columns 11
3.2.3 Calibration 11
3.2.4 Sampling 11
3.3 Results (1984-1986) 13

4 QUANTITATIVE GAS AND CONDENSATE ANALYSIS (1987-1988) 19
4.1 Development (1987-1988) 19
4.2 Methodology (1987-1988) 24
4.2.1 Analytical System 24
4.2.2 Columns 24
4.2.3 Calibration 24
4.2.4 Sampling 25
4.2.5 GC Methods 26
4.3 Results (1987-1988) 27
4.3.1 Calibration Coefficients and Curves 27
4.3.2 Results from the Lodgepole Samples 29

5 DISCUSSION 37

6 CONCLUSION 43

APPENDICES

Appendix 1 PERMEATION DEVICES 45
Appendix 2 CALIBRATION OF THE FPD THROUGH THE VARIAN DS 651 CHROMATOGRAPHY DATA SYSTEM 47
Appendix 3 CALCULATIONS AND DATA 49
Correction of 0.2 uL Liquid Results 49
Combine Liquid and Vapour Fractions to Obtain an Analysis on a Sample Basis 50
Combine Gas and Condensate Results to Obtain an Analysis on a Total Gas Effluent Basis 51
Comments on the Calculations 52
Raw Data and Results 53

Appendix 4 CHROMATOGRAMS 71

REFERENCES 139

FIGURES AND TABLES

FIGURES

		Page
1	Schematic of a Gas Chromatograph	5
2	Cross-Sectional View of the Flame Photometric Detector	5
3	Cross-Sectional View of the Flame Ionization Detector	6
4	Chromatogram of a Sample Containing Low Levels of Hydrogen Sulphide on the Porapak PS Column	9
5	Chromatogram of a Sample Containing High Levels of Hydrogen Sulphide on the Porapak PS Column	9
6	Chromatogram of a Sour Gas Sample on the 1,2,3, Tris (2-cyanoethoxy) propane Column	10
7	Schematic of the Mass Flow Controller and Permeation Device Set-up	10
8	Carbon Disulphide Calibration Curve	14
9	Carbonyl Sulphide Calibration Curve	15
10	Schematic for Relays	20
11	Schematic of the Apparatus Used to Flash the Condensates	20
12	Chromatogram of a Sour Gas Sample on the Porapak-Porapak Column Combination	22
13	Chromatogram of a Sour Gas on the 1,2,3 Tris (2-cyanoethoxy) Propane-Deactigel Column Combination	22
14	Chromatogram of the Gas Fraction from a Condensate Sample	38
15	Chromatogram of the Liquid Fraction from a Condensate Sample	38

TABLES

1	Retention Times of Compounds on the Porapak PS Column	8
2	Retention Times of Compounds on the 30% TCEP + 5% H_3PO_4 Column	8
3	Data for CS_2 Calibration Curve	13
4	Data for COS Calibration Curve	13
5	Tabulation of the COS and CS_2 Analysis of the Lodgepole Gas Samples (1986)	16
6	Tabulation of the COS and CS_2 Analysis of the Lodgepole Condensate Samples (1986)	17
7	Retention Times of Compounds on Porapak-Porapak Column Combination	23
8	Retention Times of Compounds on TCEP-Deactigel Column Combination	23
9	Calibration Data (1988)	28
10	Concentration of Sulphur Compounds in the Condensate Samples, 13-12 Well (1984)	30
11	Concentration of Sulphur Compounds on a Sample Basis, 13-12 Well (1984)	31
12	Recombination for Sulphur Compound Analysis on a Total Gas Effluent Basis, 13-12 Well (1984)	31
13	Concentration of Sulphur Compounds in the Condensate Samples, 0-2 Well (1984)	32
14	Concentration of Sulphur Compounds on a Sample Basis, 10-2 Well (1984)	33

TABLES (cont'd)

15 Recombination for Sulphur Compound Analysis on a Total Gas Effluent Basis, 10-2 Well (1984) 33
16 Concentration of Sulphur Compounds in the Condensate samples, 13-12 Well (1987, Analysed Within 6 Hours) 34
17 Concentration of Sulphur Compounds on a Sample Basis, 13-12 Well (1987, Analysed Within 6 Hours) 34
18 Recombination for Sulphur Compound Analysis on a Total gas Effluent Basis, 13-12 Well (1987, Analysed Within 6 Hours) 35
19 Concentration of Sulphur Compounds in the Condensate Sample, 13-12 Well (1987, Analysed After 7 Months) 35
20 Concentration of Sulphur Compounds on a Sample Basis, 13-12 Well (1987, Analysed After 7 Months) 36
21 Recombination for Sulphur Compound Analysis on a Total Gas Effluent Basis, 13-12 Well (1987, Analysed After 7 Months) 36
22 Tabulation of the Sulphur Compound Analysis on a Total Gas Effluent Basis for the 1984 and 1987 Samples 41
23 Exposure Concentrations Relative to the 20 ppm H_2S Evacuation Concentration and Threshold Odour Concentrations 41

SUMMARY

Recommendation 7 in the Hazard to Human Health section of the Lodgepole Blowout Report (D 84-9) stated: "The ERCB should attempt to identify all of the gaseous contaminants, in addition to H_2S and SO_2, which could be produced by a sour gas well, since other components could also have biological significance. This type of physical chemical analysis could be carried out on material safely obtained from an existing well or wells." With reference to the viscose rayon industry, concern was placed on the synergistic effects small concentrations of carbon disulphide and carbonyl sulphide may have in the presence of H_2S. The study was thus focused on identifying and quantifying the sulphur compounds in a sour gas well.

When research and commercial laboratories were contacted regarding their capabilities to analyse high-pressure sour gases and condensates for trace sulphur compounds in the presence of high concentrations of H_2S, their response indicated that the methodology was still in the development stage or that it did not meet the requirements for this study. The ERCB Chemical Research Laboratory was then asked to research and develop this technique.

Condensate and gas samples were taken in 1984 during the well testing operations of two wells, located at 13-12-48-12W5 (13-12) and 10-2-48-12W5 (10-2). By the end of 1985 the methodology to quantitatively analyse the gas samples had been developed, but to quantitatively analyse the condensate samples the existing equipment required modification. By early fall of 1987 the methodology to analyse the condensates had been developed and the 13-12 well was re-sampled and analysed to compare these results with the results from the 1984 samples.

The following table contains the concentrations of sulphur compounds in parts per million (ppm) on a volume/volume ratio that were determined to be in the total gas effluent from the reservoir. These results were calculated by recombining the sulphur compound concentrations that were found in the gas and condensate samples taken from the high-pressure separator (1984) or the wellhead separator (1987).

SULPHUR COMPOUND ANALYSIS ON A TOTAL GAS EFFLUENT BASIS

Compound	10-2 Well Sampled 1984 Analysed 1987 (ppm)	13-12 Well Sampled 1984 Analysed 1987 (ppm)	13-12 Well Sampled 1987 Analysed 1987 (within 6 hrs) (ppm)	13-12 Well Sampled 1987 Analysed 1988 (after 7 mos) (ppm)
Carbonyl Sulphide	50	54	67	NA
Methyl Mercaptan	137	71	23	32
Ethyl Mercaptan	166	72	22	33
i-Propyl Mercaptan	79	52	26	39
n-Propyl Mercaptan	32	30	14	13
s-Butyl Mercaptan	52	50	35	45
n-Butyl Mercaptan	11	13	6	5
Carbon Disulphide	LD	LD	LD	LD

Note: LD Less than detection limit (5-10 ppm).
NA Not analysed.

To compare the total gas effluent concentrations with the relative concentrations a person or animal may have been exposed to during the time the 13-12 well was out of control, a concentration ratio of 250 000 ppm to 20 ppm for H_2S was employed; the 13-12 well contained 25% HS and the evacuation concentration for H_2S is 20 ppm. The following table contains the theoretical, relative concentrations a person or animal may have been exposed to in an area where the H_2S level had reached 20 ppm, as well as some threshold odour concentrations.

EXPOSURE CONCENTRATIONS RELATIVE TO THE 20 ppm H_2S
EVACUATION CONCENTRATION AND THRESHOLD ODOUR CONCENTRATIONS

Compound	13-12 Well Total Gas Effluent Concentration (ppm)	Relative Exposure Concentration (ppm)	*Threshold Odour Concentration (ppm)
Carbonyl Sulphide	54	0.004 3	no data
Methyl Mercaptan	71	0.005 7	0.000 000 2 to 0.041
Ethyl Mercaptan	72	0.005 8	0.000 098 to 0.003
i-Propyl Mercaptan	52	0.004 2	no data
n-Propyl Mercaptan	30	0.002 4	0.000 06 to 0.02
s-Butyl Mercaptan	50	0.004 0	no data
n-Butyl Mercaptan	13	0.001 0	0.000 4
Carbon Disulphide	LD	-	0.016 to 0.021

Note: LD Less than detection limit (5-10 ppm).
* Data provided by Dr. Shekar Viswanathan, Clayton Environmental Consultants.

Since the sense of smell varies from person to person, threshold odour concentrations are very subjective. As indicated by the data, the relative exposure concentrations would easily have been within the detectable odour range for some people.

The sulphur compound analysis was originally performed on a Varian Vista 6000 Gas Chromatograph (GC) equipped with a single column, a dual-flame photometric detector (FPD), and a Varian 4270 integrator. To quantify the condensate samples,this system was upgraded to incorporate a flame ionization detector, an effluent splitter, dual columns, and a backflush relay. The 4270 integrator was replaced by a Varian DS 651 Chromatography Data System, which was used to control the GC and to record, store, and manipulate the data output from the two detectors. The effluent splitter was used to direct part of the sample to each detector for simultaneous determination of the hydrocarbon and sulphur compounds. Calibration standards for the sulphur compounds were obtained from permeation devices that were used in combination with a Linde FM 4575 mass flow controller. The hydrocarbon scan was only used qualitatively: to ensure that the hydrocarbons were adequately separated from the sulphur compounds and were not interfering with the sulphur signal.

Comparing the 6-hour analysis to the 7-month analysis of the 13-12 well 1987 samples indicates the results are reliable within approximately 30%. With this study a method was being developed to analyse existing samples, and when the results were being

manipulated (4 years later) additional information such as reservoir rate data and physical sample data was required. However, the methodology to analyse high-pressure sour gases and condensates for trace sulphur compounds has been developed and the information acquired in the areas of instrumentation, sample handling (both field and laboratory), and data manipulation will contribute to more accurate determination of future samples.

1 INTRODUCTION

Recommendation 7 in the Hazard to Human Health section of the Lodgepole Blowout Report (D 84-9) stated: "The ERCB should attempt to identify all of the gaseous contaminants, in addition to H_2S and SO_2, which could be produced by a sour gas well, since other components could also have biological significance. This type of physical chemical analysis could be carried out on material safely obtained from an existing well or wells."

During well testing operations in June and July of 1984, two sour gas wells located at 10-2-48-12W5 and 13-12-48-12W5 had condensate samples and gas samples taken from the high-pressure separator, low-pressure separator, stock tank, and boot. The purpose of this study was to identify and quantify the sulphur compounds in these samples, with special emphasis placed on carbonyl sulphide (COS) and carbon disulphide (CS_2). A Varian Vista 6000 GC equipped with a dual-flame FPD was used for this analysis.

In February of 1986 a report "Sulphur Compounds in Natural Gas Study" was written and presented to the Board and then to the Lodgepole Panel. With the equipment configuration at that time, quantitative results could be obtained only for the gas samples. Without quantitative results for the condensate samples the information presented was insufficient for an overall study of the sulphur compounds in the reservoir.

In May through November of 1986 the existing equipment was modified to enable quantitative analysis of the condensate samples. Over the following year the methodology for sour gas analysis was improved and the methodology for condensate analysis was developed. In October of 1987 the 13-12 well was re-sampled and re-analysed.

The methodology and results are divided into two sections: Quantitative Gas and Qualitative Condensate Analysis (1984-1986), and Quantitative Gas and Condensate Analysis (1987-1988). The first section covers the information that was presented in the 1986 report "Sulphur Compounds in Natural Gas Study". The second section describes the technique and methodology that is presently used to quantitatively analyse sour gas and condensate samples. The results from the Lodgepole samples are presented in this section on a total sample basis (gas and condensate) and on a total gas effluent basis, which mathematically recombines the results from the gas and condensate samples.

2 THEORY

2.1 General Chromatography

Chromatography can be defined as the separation of a multicomponent sample into its various components. The separation process, which takes place on the column, is based on the differences in rates at which the individual components migrate through a stationary medium under the influence of a mobile phase. In gas chromatography the mobile phase is the carrier gas, usually helium or nitrogen, and the stationary phase is the column packing or a liquid that thinly coats the column packing.

The sample can be introduced either with a syringe or by a sample loop.

Syringe injection incorporates two techniques: on-column injection and flash vaporization. With on-column injection the syringe delivers the sample directly onto the top of the column. With flash vaporization the sample is injected into a heated zone called the injector port. There the sample volatilizes and then is swept onto the column by the carrier gas.

Gas samples are more conveniently injected via a gas sampling loop. After sufficiently purging the loop with the sample, a valve is actuated which aligns the sample loop with the carrier gas and the column. The carrier gas then flushes the sample out of the loop and onto the column.

As the sample travels through the column it separates into bands of individual components. Separation depends upon the affinity a particular component has for the stationary phase. A component that is strongly attracted to the stationary phase will be retained longer than a component that has little attraction to the stationary phase.

The selection of the column is very important in gas chromatography. The various types of columns are packed, capillary, and fused silica or megabore. Packed columns consist of a tubing filled with solid particles of fairly uniform shape and size. The tubing material can be stainless steel, copper, nickel, glass, or even teflon. In gas-solid chromatography active solid particles such as molecular sieves or porous polymers are the stationary phase and separation is achieved through a surface adsorption process. In gas-liquid chromatography the stationary phase is a liquid supported on an inert solid matrix and separation is based on partitioning or differential solubility in the stationary phase.[1] Since most stationary phases were developed for a particular type of separation, scientific companies (manufacturers) will usually provide application information on their various stationary phases.

The column is contained in a temperature programmable oven. The chromatogram can be run either with the oven at a constant temperature (isocratic) or with the oven starting at low temperature to ensure adequate separation of the volatile components and then increasing the temperature stepwise to elute the higher molecular weight components in a reasonable time. Temperature programming can decrease the analysis time and increase the resolution of the separation.

As each component band elutes off the column it enters the detector where electronically the component is measured. This electronic signal is then transferred to an integrator where a chromatogram is drawn. Each peak on the chromatogram corresponds to a particular component in the sample. The larger the electronic signal, the larger the peak, and thus the larger the integral count of that peak. See Figure 1 for a schematic of a gas chromatograph.

Retention time is the time, measured in minutes, that elapses from the point of the injection of a sample to the point of the detection of a component in the sample. Therefore, under certain operating conditions a compound may be separated from a mixture and identified by its retention time.

The type of detector employed depends upon the type of sample being analysed. An FPD is used for the analysis of sulphur or phosphorus containing compounds, whereas a flame ionization detector (FID) is used for the analysis of organic compounds, such as hydrocarbons. [2,3]

2.2 Flame Photometric Detector

The detection principle of the FPD is based on the chemiluminescent emission from excited sulphur (S_2*) or phosphorus (HPO*) species. The column effluent is burnt in a reducing, hydrogen-air flame while measuring a selected spectral portion of the light emission from this flame. In the phosphorus mode a narrow bandpass interference-type filter with light transmission peaked at 530 nanometres (nm) is used to select the green light emitted from phosphorus compounds, while in the sulphur mode a broad bandpass coloured-glass filter with light transmission peaked at 365 nm is used to select the blue light emitted from sulphur compounds. [4]

Both single- and dual-flame FPDs are manufactured. In a single-flame system both sample decomposition and optical emission occur in the same flame[5]. As a result quenching and flame-out problems may occur. Quenching may occur when a hydrocarbon elutes simultaneously with a sulphur compound. The S_2* species, instead of emitting light at the usual wave-length, lose this energy through molecular collisions, which leads to a decrease in detector response. Flame-out occurs when a large amount of hydrocarbon enters the flame, starving it of oxygen and causing it to extinguish. In a dual-flame FPD sample decomposition occurs in the first flame whereas excitation and optical emission occur in the second flame. As a result a dual-flame system experiences fewer problems than does a single-flame system.

In the Varian FPD the hydrocarbon and air flow-rates are set as follows: hydrogen at 140 millilitres per minute (mL/min); air #1 at 80 mL/min; and air #2 at 170 mL/min (see Figure 2). The sum of the two air supplies consumes approximately 70% of the hydrogen supplied to the burner. Therefore, both flame #1 and flame #2 are operated in a hydrogen-rich environment.

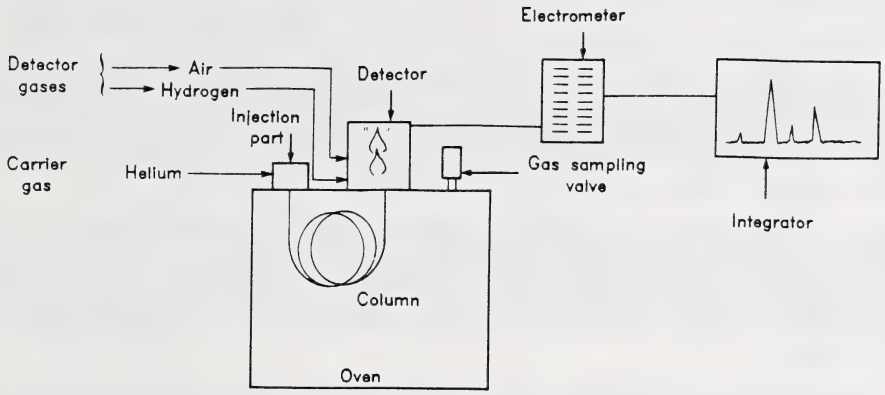


FIGURE 1: SCHEMATIC OF A GAS CHROMATOGRAPH

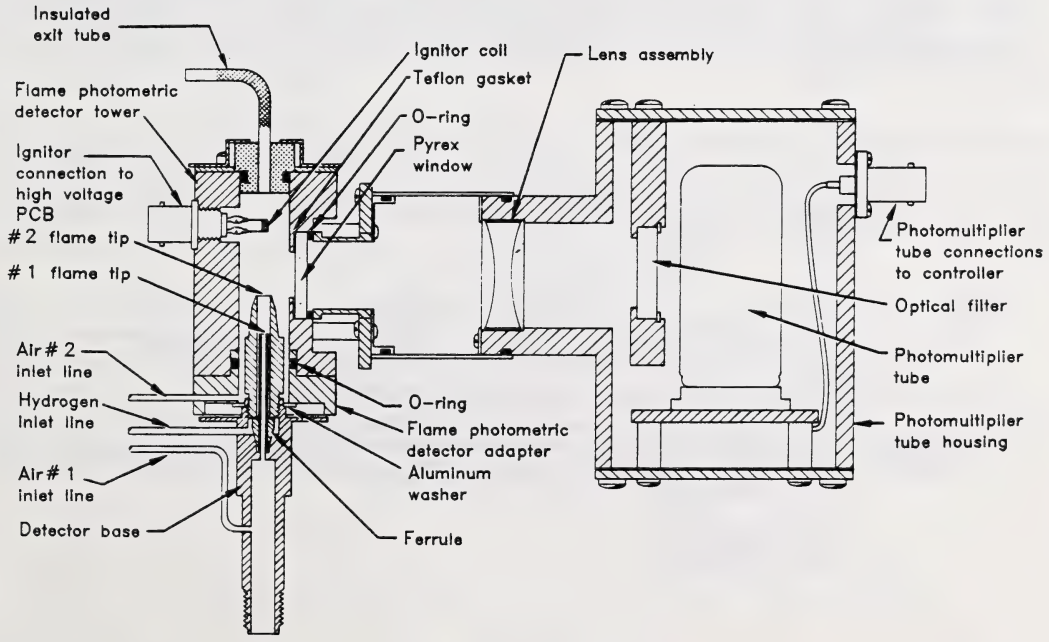


FIGURE 2: CROSS-SECTIONAL VIEW OF THE FLAME PHOTOMETRIC DETECTOR
(Courtesy of Varian Associates, Inc.)

Hydrogen and air #1 combine to form flame #1. As the compounds elute off the column they are mixed with air #1 before they enter the first flame. In flame #1 the sulphur compounds are irreversibly decomposed to H_2S. The unburned hydrogen and combustion products from flame #1 then combine with air #2 to form flame #2. Here the H_2S from the decomposed sulphur compounds reacts with hydrogen atoms to yield S_2 molecules. In the hydrogen-rich inner-conical region of flame #2, the S_2 molecules become excited and as they lose their excess energy they emit a pale blue light which passes through the optical filter and is detected by the photomultiplier tube. [6]

The detector response for sulphur is not linear with sulphur concentration; it varies approximately as the square of the sulphur atom flow into the flame. The selectivity of sulphur to carbon varies from 1000 grams (g) of carbon per gram of sulphur at low sulphur content, to better than 1 000 000 g of carbon per gram of sulphur at high sulphur content.

2.3 Flame Ionization Detector

The detection principle of the FID is based on the chemical ionization of organic compounds upon combustion. The column effluent mixes with hydrogen and then enters an air-hydrogen flame which is polarized in an electrostatic field. The combustible sample components are then ignited and ionized. The ions, which collect at the electrodes, produce a current that is electronically measured. There is little difference between various manufacturers' designs for FIDs. In the Varian FID, the hydrogen and air flow-rates are 30 mL/min and 300 mL/min, respectively (see Figure 3).

The FID does not respond to water or permanent gases such as nitrogen, oxygen, or carbon dioxide. The response is roughly proportional to the number of carbon atoms, but it diminishes with the substitution of electron-capturing groups, such as halogens, amines, or hydroxyls.

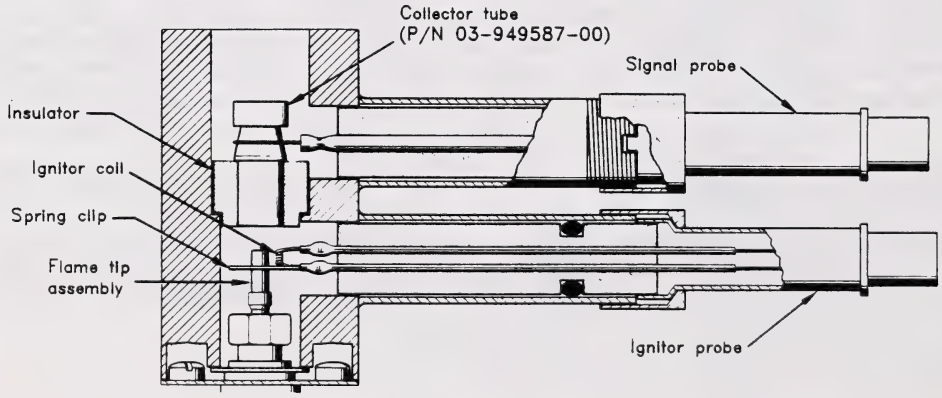


FIGURE 3: CROSS-SECTIONAL VIEW OF THE FLAME IONIZATION DETECTOR
(Courtesy of Varian Associates, Inc.)

3 QUANTITATIVE GAS AND QUALITATIVE CONDENSATE ANALYSIS (1984-1986)

3.1 Development (1984-1986)

In addressing recommendation 7 in the Hazard to Human Health section of the Lodgepole Blowout Report (D 84-9), the ERCB Chemical Research Laboratory was asked to identify and quantify the sulphur compounds in a sour gas well. Emphasis was placed on COS and CS_2 determination.

The methodology development started in July of 1984. The Varian Vista 6000 GC was originally designed for a single column analysis with either syringe or gas sampling loop injection and with flame photometric detection. The analysis involved detecting parts per million (ppm) levels of COS and CS_2 in samples that contained high concentrations of H_2S: 25% or 250 000 ppm.

After some experimental work it was found that two columns of different polarity were required, one to analyse for COS and the other for CS_2.

A Porapak PS^R, acetone-washed, column was used for the CS_2 analysis. This column eluted the sulphur compounds in ascending order of their boiling points: H_2S first, followed by COS and then the mercaptans. Table 1 lists the retention times of various compounds of this column. Separation of H_2S from COS was adequate in samples that contained low H_2S concentrations, but with the Lodgepole samples COS eluted on the tail of the H_2S peak (see Figures 4 and 5).

A 30% 1, 2, 3 tris (2-cyanoethoxy) propane (TCEP) + 5% phosphoric acid (H_3PO_4) column was used for the COS analysis. This column eluted COS ahead of H_2S allowing it to be quantified without H_2S interference, but it inadequately separated CS_2 and the mercaptans (see Figure 6). Table 2 lists the retention times for H_2S, COS, and some hydrocarbons on this column.

Permeation devices for COS and CS_2 were used to calibrate the FPD. These devices have a permeable membrane through which a compound is emitted at a specified rate in nanograms per minute. A diluent gas is mixed with the permeating compound to form a calibration mixture (see Appendix 1). A range of concentrations can be obtained by varying the flow-rate of the diluent gas, which was nitrogen.

The Lodgepole gas and condensate samples were analysed using the described system. Quantitative results were obtained for the gas samples, but the method lacked the sophistication required to obtain quantitative results for the condensate samples. In February of 1986 a report "Sulphur Compounds in Natural Gas Study" documenting the results obtained, was presented to the Board and to the Lodgepole Panel. The Lodgepole Panel believed that quantitative analyses of the condensates, not only for COS and C_2S but also for the mercaptans, was required to complete the study.

TABLE 1 RETENTION TIMES OF COMPOUNDS ON THE PORAPAK PS COLUMN

Compound	Retention Time* (minutes)
Methane	0.47
Carbon Dioxide	0.66
Ethane	1.52
Hydrogen Sulphide	3.02
Propane	4.60 to 5.00
Carbonyl Sulphide	4.86
Methyl Mercaptan	11.09
Ethyl Mercaptan	13.86
Dimethyl Sulphide	14.16
Carbon Disulphide	14.66
i-Propyl Mercaptan	15.45
t-Butyl Mercaptan	15.42
n-Propyl Mercaptan	16.45
Sulphur Dioxide	17.42
s-Butyl Mercaptan	17.82
i-Butyl Mercaptan	17.90
n-Butyl Mercaptan	18.59
Dimethyl Disulphide	19.83

* The retention times were obtained using the following GC parameters. The oven was temperature programmed to initially hold 35°C for 5 minutes, then to increase at a rate of 10°C per minute until 160°C was reached, and then to hold 160°C for 10 minutes. The injector was at 210°C. The detector was at 220°C. The helium flow-rate was at 30 mL/min.

TABLE 2 RETENTION TIMES OF COMPOUNDS ON THE 30% TCEP + 5% H_3PO_4 COLUMN

Compound	Retention Time* (minutes)
Methane	1.12
Ethane	1.16
Propane	1.28
Butane	1.43
Carbonyl Sulphide	2.06
Pentane	2.16
Hydrogen Sulphide	4.23
Carbon Disulphide	9.13

* The retention times were obtained using the following GC parameters. The oven was temperature programmed to initially hold 35°C for 5 minutes, then to increase at a rate of 10°C per minute until 80°C was reached, and to hold 80°C for 10 minutes. The injector was at 120°C. The detector was at 150°C. The helium flow-rate was at 30 mL/min.

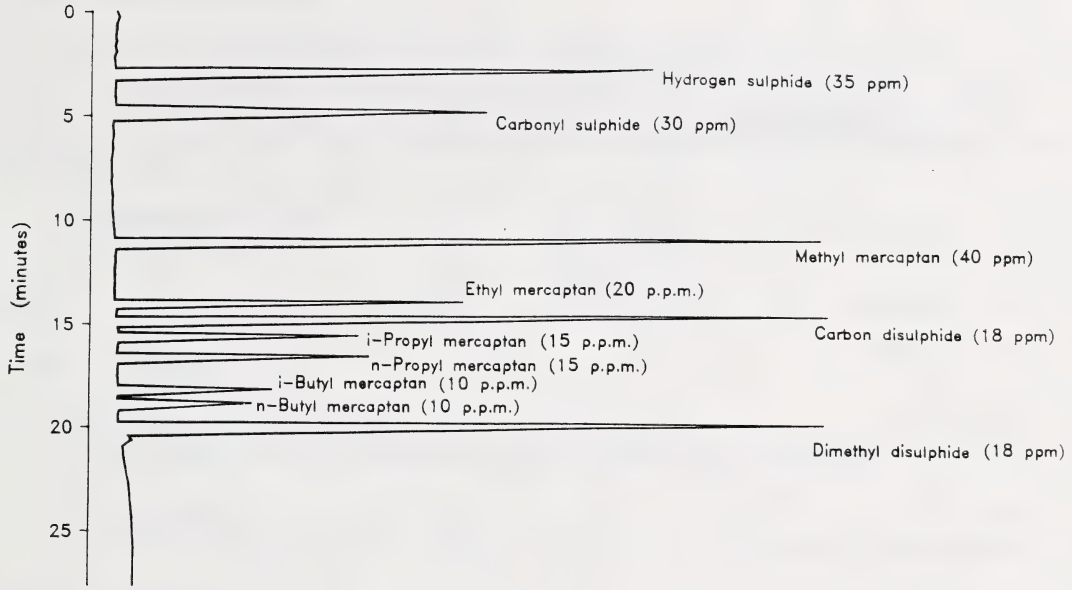


FIGURE 4: CHROMATOGRAM OF A SAMPLE CONTAINING LOW LEVELS OF HYDROGEN SULPHIDE ON THE POROPAK PS COLUMN

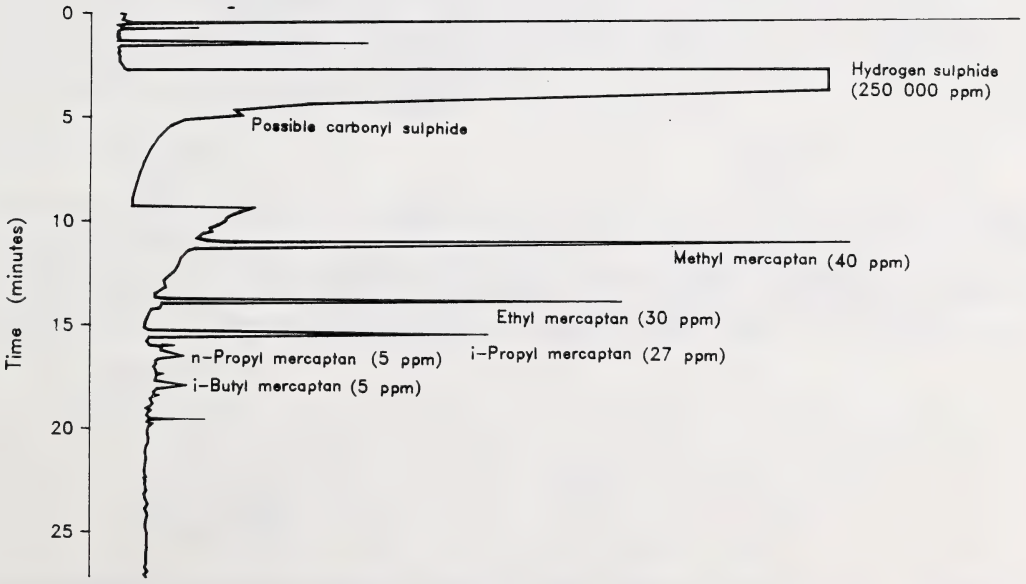


FIGURE 5: CHROMATOGRAM OF A SAMPLE CONTAINING HIGH LEVELS OF HYDROGEN SULPHIDE ON THE POROPAK PS COLUMN

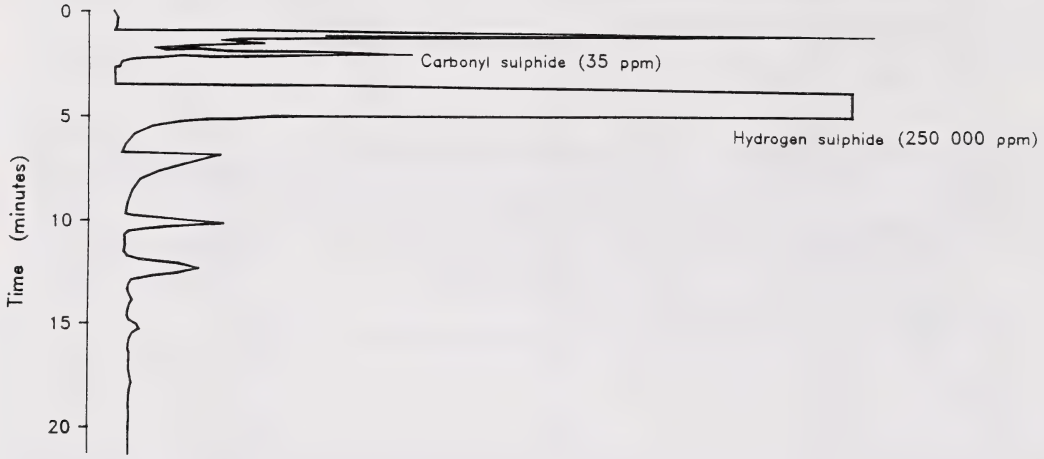


FIGURE 6: CHROMATOGRAM OF A SOUR GAS SAMPLE ON THE 1,2,3 TRIS(2-CYANOETHOXY) PROPANE COLUMN

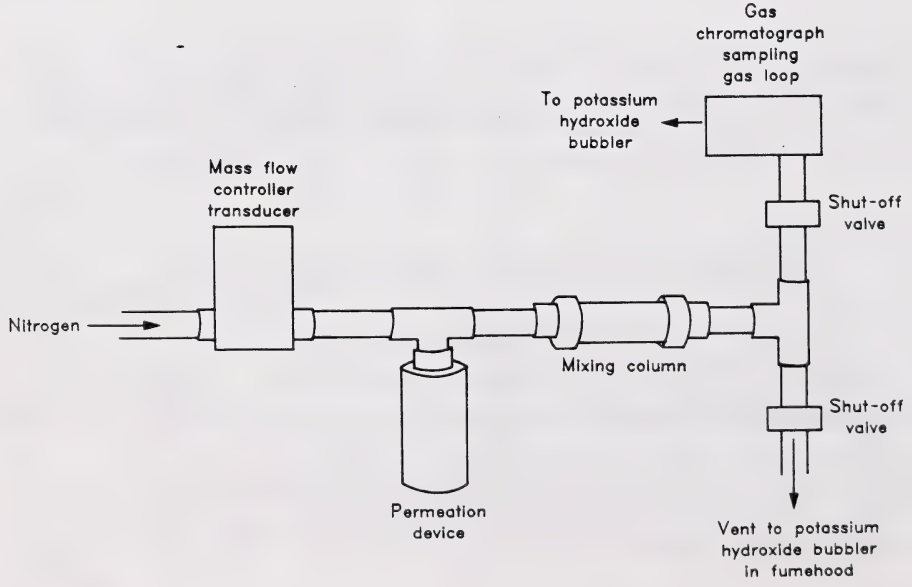


FIGURE 7: SCHEMATIC OF THE MASS FLOW CONTROLLER AND PERMEATION DEVICE SET-UPLPHIDE ON THE POROPAK PS COLUMN

3.2 Methodology (1984-1986)

3.2.1 Analytical System

A Varian Vista 6000 GC fitted with a dual-flame photometric detector was used. The chromatograms and peak areas were recorded with a Varian 4270 integrator. Sample injection was done either with a 250-microlitre (uL) teflon gas sampling loop or with a gas-tight syringe. Ultra-high purity gases from Matheson were used for the carrier and detector gases.

Carrier Gas:	He	= 30 mL/min
Detector Gases:	Air 1	= 80 mL/min
	Air 2	= 170 mL/min
	H_2	= 140 mL/min

3.2.2 Columns

- Mercaptan and CS_2 Analysis
  6' x 1/8" stainless steel, Porapak PS, acetone-washed, 80/100 mesh

- COS Analysis
  15' x 1/8" stainless steel, 30% TCEP + 5% H_3PO_4 on Chromasorb P, 80/100 mesh

3.2.3 Calibration

G-Cal permeation devices for CS_2 and COS were used. A Linde FM 4575 mass flow controller was used to measure and control the flow of the diluent gas (Matheson ultra-high purity nitrogen). The calibration mixture was passed through a mixing chamber (a 1/2" x 3" teflon tube filled with 3-mm silanized glass beads) and then through a tee connector which divided the flow. Part of the calibration mixture went to the GC sampling loop while part of it was vented to a KOH bubbler in the fume hood (Figure 7). The exhaust end of the gas sampling loop was also connected to a KOH bubbler which was vented into the fume hood. Calibration curves were constructed by plotting peak area versus concentration in ppm on a volume/volume basis.

3.2.4 Sampling

Gases: A stainless steel tee was connected to one of the stainless steel sample bombs. Also connected to the tee was 0-1000 psi gauge and a stainless steel valve which had been fitted with a 1/8" tubing connector. The 1/8" tubing connector allowed the sample bomb to be connected directly to the GC gas sampling loop. To sample the gas, the outlet valve was left closed, while the bomb valve was opened and then closed. This caused some

of the gas to be caught between the two valves. The bomb pressure would also be displayed on the gauge. Then the second valve was opened, allowing the gas to flow through the sampling loop. This was repeated to ensure adequate purging. After a 10-second period, which allowed the sampling loop's pressure to equalize, the gas sampling valve was actuated and the chromatographic run was started.

Some of the samples were at very low positive, or even negative gauge pressure. Thus, the sample either had to be pulled through the sampling loop by means of a vacuum, or be pressurized. When the samples were being analysed for CS_2 our hot water bath was not in working order, so the vacuum method was used for sampling. Both sampling methods, vacuum and bomb pressurization, were tried when the COS analyses were performed. The hot water bath heated to only 130°F. This was not hot enough to create sufficient pressure to purge the sampling loop. The bombs were then filled to atmospheric pressure with a lithium chloride (LiCl) solution (100 g LiCl per 500 mL water) and then immersed in the hot water bath. This produced enough pressure for about two GC runs. There was not enough pressure left to repeat the CS_2 analysis.

The high-pressure samples were also placed in the hot water bath and then re-sampled to compare the results of the heated runs to those of the room temperature runs.

Condensates: To sample the condensates, a stainless steel valve was connected to one end of the sample bomb. Connected to the valve was a 1/4" swagelok fitting which contained a septum. With the second valve closed, the bomb valve was opened and then closed, trapping condensate in the space between the two valves. Then the second valve was opened and then closed, allowing condensate to enter the area between the valve and swagelok fitting.

The high-pressure condensates would partially flash vaporize when the sample entered the fitting area. Using a 100-uL gas-tight syringe, a sample of the flashed vapour was taken and injected into the GC. Then some of the condensate-vapour mixture was transferred (using a gas-tight syringe) to a 300-mL silanized glass bulb. Then the sample bulb was spiked with either COS or CS_2 and a chromatogram was rerun.

With the low-pressure samples, flashing did not occur in the fitting area, so 20 to 100 uL of the condensate was transferred to a 300-mL silanized glass bulb and the above procedure was followed.

Because of the method of sampling, only qualitative results could be obtained for the condensate samples. There is always a problem in obtaining accurate results when one deals with obtaining samples from vessels at high pressure containing two phases: in this case, gas and liquid.

3.3 Results (1984-1986)

TABLE 3 DATA* FOR CS_2 CALIBRATION CURVE
Concentration CS_2 versus Peak Area

Concentration (ppm)	Peak Area
2.7	15 574
4.6	43 181
9.06	185 880
13.6	456 747
19.3	817 746

* The data was obtained using a Porapak PS, acetone-washed, column and the following GC parameters. The oven was temperature programmed to initially hold 35°C for 5 minutes, then to increase at a rate of 10°C per minute until 160°C was reached, and to hold 160°C for 10 minutes. The injector was at 210°C. The detector was at 220°C. The helium flow-rate was at 30 mL/min (see Figure 8).

TABLE 4 DATA* FOR COS CALIBRATION CURVE
Concentration COS versus Peak Area

Concentration (ppm)	Peak Area (Count)	Concentration (ppm)	Peak Area (count)
2.2	2 212	40	248 473
3	4 804	46	338 508
4	3 974	50	385 589
5	5 024	68	816 172
10	17 050	94	1 430 052
15	36 592	100	1 563 916
20	63 112	120	2 364 248
22	99 039	145	3 434 118
25	110 973	171	4 720 290
27	126 270	200	6 292 233
31.6	173 433		

* The data was otained using a 30% TCEP + 5% H_3PO_4 on Chromasorb P column and the following GC parameters. The oven was temperature programmed to initially hold 35°C for 5 minutes, then to increase at a rate of 10°C per minute until 80°C was reached, and to hold 80°C for 10 minutes. The injector was at 120°C. The detector was at 150°C. The helium flow-rate was at 30 mL/min (see Figure 9).

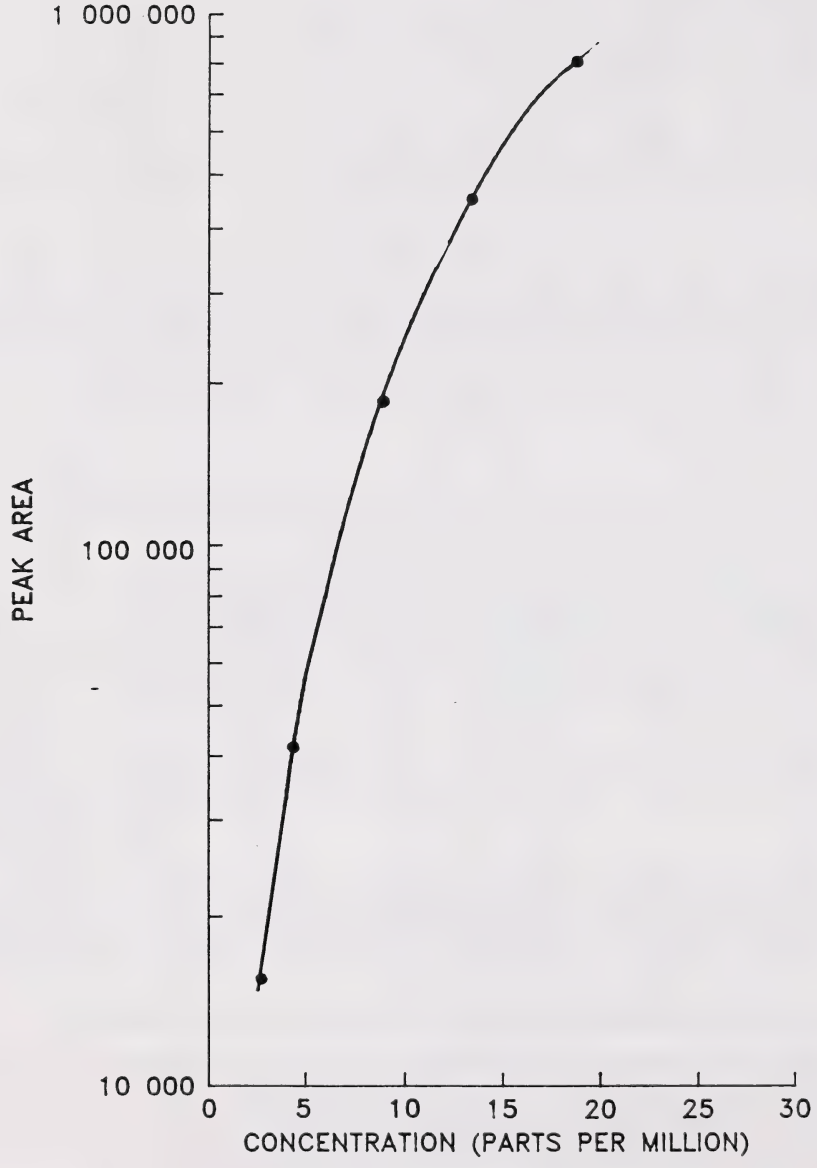


FIGURE 8: CARBON DISULPHIDE CALIBRATION CURVE

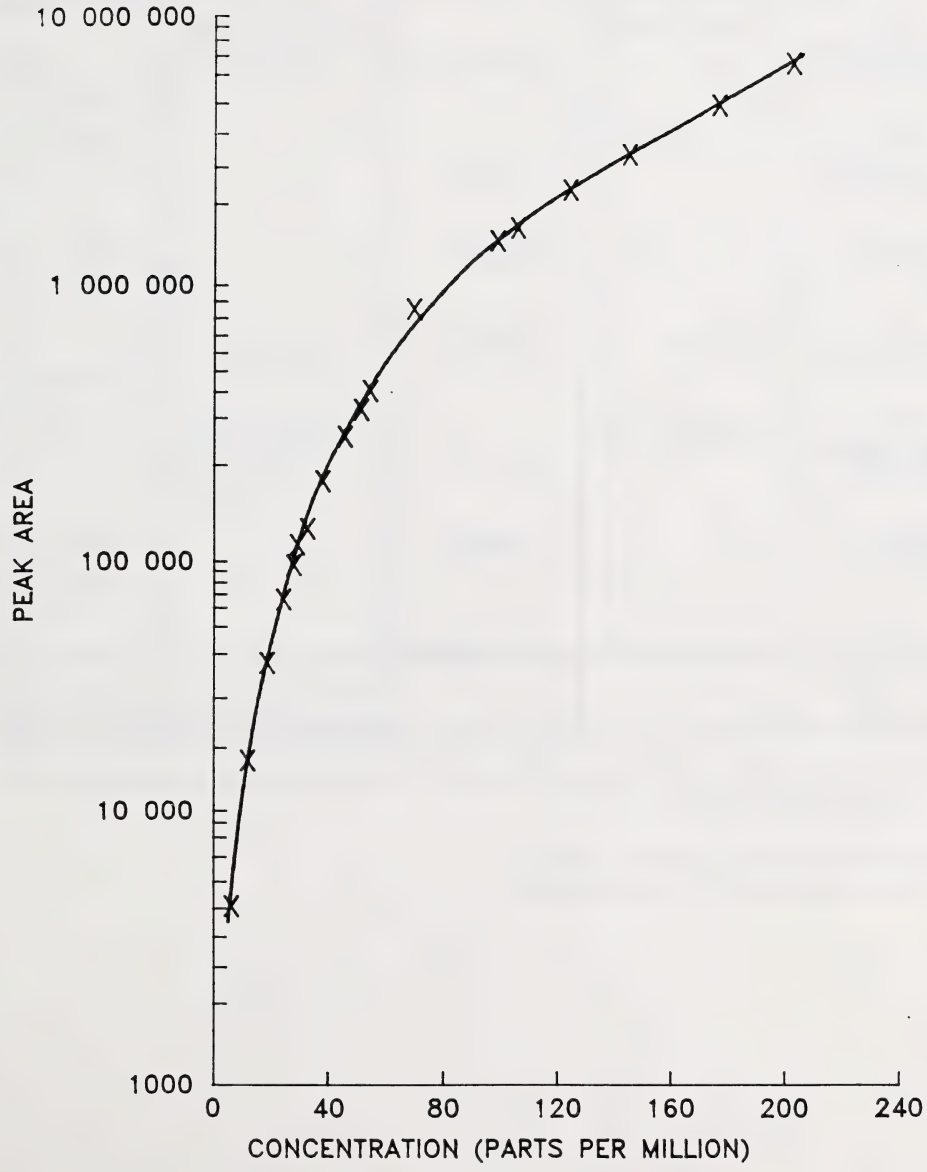


FIGURE 9: CARBONYL SULPHIDE CALIBRATION CURVE

TABLE 5 TABULATION OF THE COS AND CS_2 ANALYSES OF THE LODGEPOLE GAS SAMPLES (1986)

Sample Description	CS_2 ppm High Pressure	CS_2 ppm Vacuum Sample	COS ppm High Pressure	COS ppm Vacuum Sampled	COS ppm LiCl & Heat
G1-684 High-pressure Separator	undetectable	-	40 (room temp) 42 (heated)	-	-
G2-684 Low-pressure Separator	8.2	-	-	66	78
G3-684 Boot	-	15.7*	-	142	170
G4-684 Stock Tank	-	18*	-	?	20
G1-784 High-pressure Separator	undetectable	-	46 (room temp) 43 (heated)	-	-
G2-784 Boot	-	(4)?	-	130	153
G3-784 Low-pressure Separator	-	undetectable	-	65	76

* CS_2 definitely present but values may not be accurate due to sampling method.
? Results questionable.

684 samples from well 10-2-48-12W5
784 samples from well 13-12-48-12W5

TABLE 6 TABULATION OF THE COS AND CS_2 ANALYSES OF THE LODGEPOLE CONDENSATE SAMPLES (1986)

Sample Description	CS_2 Flash Vaporized	CS_2 Vapour from Cond.	COS Flash Vaporized	COS Vapour from Cond.
P1-684 High-pressure Separator	undetectable	undetectable	undetectable	undetectable
P2-684 Low-pressure Separator	-	detected	-	detected
P3-684 Boot	-	detected	-	detected
P4-684 Stock Tank	-	detected	-	undetectable
G4-784 High-pressure Separator	undetectable	detected	detected	undetectable
G5-784 Boot	-	detected	-	detected
G6-784 Low-pressure Separator	-	detected	-	detected

684 samples from well 10-2-48-12W5
784 samples from well 13-12-48-12W5

4 QUANTITATIVE GAS AND CONDENSATE ANALYSIS (1987-1988)

4.1 Development (1987-1988)

In order to analyse the condensates, GC modifications and additional equipment were required. The GC modifications included installing a 6-port and a 10-port valve, an FID, and an effluent splitter.

The 6-port and 10-port valves were connected to a gas sampling loop relay and a stripper column and backflush relay. The stripper column and backflush relay allow portions of the sample to be isolated. The portions that are of interest are allowed to pass onto the analytical column, while the unwanted portions are backflushed from the stripper column and vented.

In this system, when the backflush relay is off, the carrier gas flows through both the stripper and the analytical column (see Figure 10). When the backflush relay is initiated the carrier gas reverses its flow through the stripper column and goes to a vent, while a make-up carrier gas flows through the analytical column and onto the detectors.

The effluent splitter was connected to the end of the analytical column in order to direct part of the column effluent to the FID and part to the FPD for simultaneous detection of the hydrocarbons and the sulphur compounds in the sample. Information from both detectors helps to determine whether or not the sulphur compounds were adequately separated from the hydrocarbon compounds or if there was hydrocarbon interference with the sulphur signal.

To record, store, and manipulate the data coming from the FID and FPD, a Varian DS 651 Chromatography Data System was purchased.

Some of the Lodgepole condensate samples were at elevated pressures and as they were released from their sample bombs, they would flash, producing a liquid phase and a vapour phase. A procedure was developed to control this flashing phenomenon and to allow both the vapour and liquid fractions to be analysed separately for sulphur compounds. Figure 11 shows the apparatus set-up for the flashing procedure. Basically, the sample bomb was connected to a trap which in turn was connected to a 500-mL gas-tight syringe. After the system was evacuated, a small amount of the condensate was released into the apparatus. The drop from bomb pressure to atmospheric pressure caused some of the condensate to flash.

The unflashed liquid was caught in the trap while the evolved vapour, which had pushed the syringe plunger out, was contained in the syringe. Both the liquid and vapour fractions were analysed for sulphur compounds.

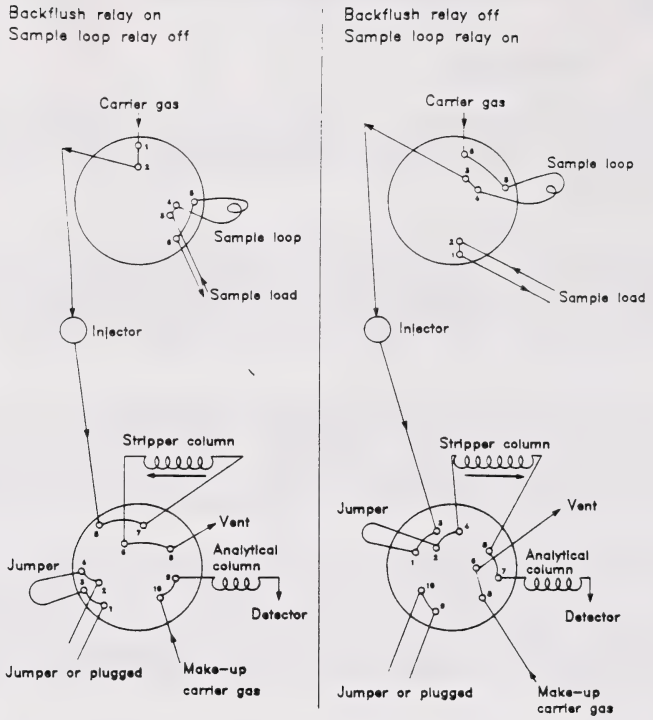


FIGURE 10: SCHEMATIC FOR RELAYS

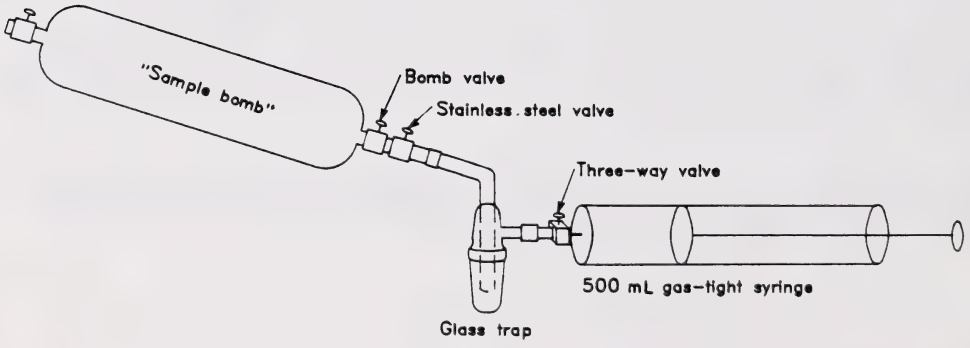


FIGURE 11: SCHEMATIC OF THE APPARATUS USED TO FLASH THE CONDENSATES

The mercaptans and CS_2 were analysed with a Porapak PS column in both the stripper and analytical positions. The sample was injected with the stripper column backflushing to vent. After the H_2S had eluted off the stripper column and was vented, but before the mercaptans had a chance to elute, the backflush relay was switched off causing the carrier gas to flow forward through the stripper column and then through the analytical column. The mercaptans and CS_2 followed the direction change of the carrier gas. After they had passed from the stripper column onto the analytical column, the backflush relay was initiated again to backflush any heavier hydrocarbons off the stripper column, while the make-up carrier gas eluted the mercaptans and CS_2 off the analytical column and onto the detectors. Using this backflush relay helped to prevent large quantities of H_2S from entering and overloading the FPD. Table 7 lists the retention times of compounds on the Porapak-Porapak column combination. See Figure 12 for a chromatogram of a sour gas on this column combination.

The samples were analysed for COS with the TCEP column in the stripper position and a deactigel column in the analytical position. Both the TCEP and deactigel column elute COS ahead of H_2S. The COS analysis incorporated a different backflush sequence than that of the mercaptan analysis. The sample was injected with the carrier gas flowing forward through both the stripper and analytical columns. Once the COS had eluted off the stripper column and onto the analytical column and before the H_2S had a chance to enter the analytical column, the backflush relay was initiated. This again prevented large quantities of H_2S from entering and overloading the FPD. Table 8 lists the retention times of compounds on the TCEP - deactigel column combination. See Figure 13 for a chromatogram of a sour gas on this column combination.

Permeation devices that were traceable through a gravimetric technique to the National Bureau of Standards (NBS) were used to calibrate the FPD for COS, CS_2, and methyl, ethyl, i-propyl, n-propyl, i-butyl, and n-butyl mercaptans (see Appendix 1). Both single point and multipoint calibration curves were constructed using the chromatography data system. Appendix 2 contains information on calibration through the chromatography data system.

The 1984 condensate samples were analysed using the described system. Fresh gas and condensate samples were taken from the meter run of the Lodgepole 13-12 well in the end of October 1987. These samples were analysed within 6 hours for mercaptans and CS_2 and within 5 days for COS. The mercaptan and CS_2 analysis was repeated 7 months later.

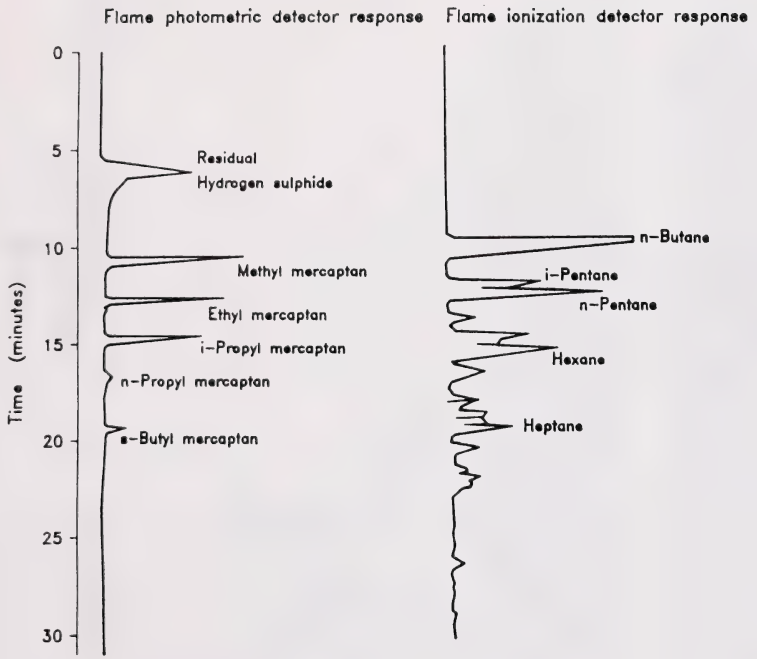


FIGURE 12: CHROMATOGRAM OF A SOUR GAS SAMPLE ON THE POROPAK-POROPAK COLUMN COMBINATION

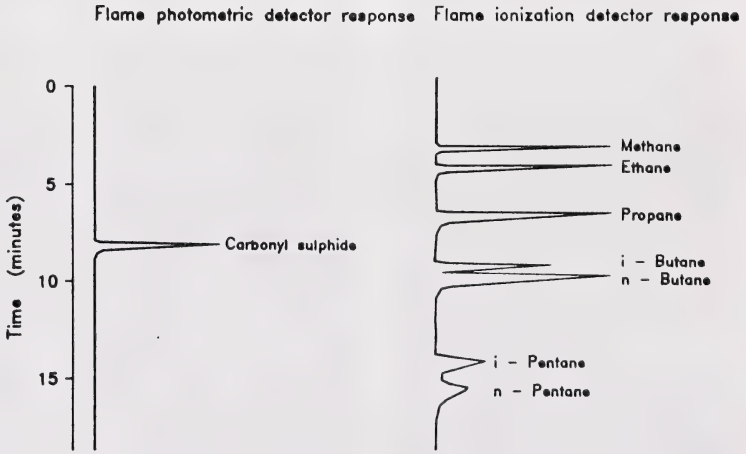


FIGURE 13: CHROMATOGRAM OF A SOUR GAS ON THE 1,2,3 TRIS (2-CYANOETHOXY) PROPANE-DEACTIGEL COLUMN COMBINATION

The column effluent passes through a splitter which directs part of the effluent to the flame photometric detector and part to the flame ionization detector for sinultaneous detection of the sulphur compounds and hydrocarbons.

TABLE 7 RETENTION TIMES* OF COMPOUNDS ON PORAPAK-PORAPAK COLUMN COMBINATION

Compound	Retention Time (minutes)	Compound	Retention Time (minutes)
i-Butane	9.63	i-Butyl Mercaptan	19.94
n-Butane	10.27	n-Hexane	20.02
Methyl Mercaptan	10.50	n-Butyl Mercaptan	21.01
i-Pentane	12.34	Dimethyl Disulphide	22.39
n-Pentane	12.83	n-Octane	23.40
Ethyl Mercaptan	12.97	n-Pentyl Mercaptan	24.81
Dimethyl Sulphide	13.49	n-Nonane	27.10
Carbon Disulphide	14.06	n-Hexyl Mercaptan	29.19
i-Propyl Mercaptan	15.40	n-Decane	30.50
n-Hexane	16.52	n-Heptyl Mercaptan	32.19
n-Propyl Mercaptan	17.01	n-Undecane	33.43
s-Butyl Mercaptan	19.59	n-Dodecane	37.90

* The retention times were obtained using the following GC parameters. The oven was temperature programmed to initially hold 90°C for 8 minutes, to increase at a rate of 10°C per minute until 170°C was reached, to hold 170°C for 4 minutes, then to increase at a rate of 20°C per minute until 200°C was reached, and to hold 200°C for 3 minutes. The system was backflushing for the first 4 minutes of the program.

TABLE 8 RETENTION TIMES* OF COMPOUNDS ON TCEP - DEACTIGEL COLUMN COMBINATION

Compound	Retention Time (minutes)
Methane	2.496
Ethane	3.433
Propane	5.991
Carbonyl Sulphide	7.513
i-Butane	8.977
n-Butane	9.589
i-Pentane	13.575
n-Pentane	14.941

* The retention times were obtained using the following GC parameters. The oven was temperature programmed to initially hold 40°C for 5 minutes, to increase at a rate of 10°C per minute until 80°C was reached, and to hold 80°C for 10 minutes. The system was switched to backflush after 4 minutes of the program had elapsed.

4.2 Methodology (1987-1988)

4.2.1 Analytical System

A Varian Vista 6000 GC equipped with a dual-flame FPD, an FID, an analytical column, a stripper column, and a backflush system was used. An effluent splitter was connected to the end of the analytical column to direct the effluent to both detectors for simultaneous determination of hydrocarbon and sulphur compounds. A Varian DS 651 Chromatography Data System was used to control the GC and to record, store, and manipulate the data output from the two detectors. The gas fractions were injected via a 250-uL teflon gas sampling loop. The liquid fractions were injected with a Hamilton 1-uL syringe. Ultra-high purity gases from Linde were used for the carrier and detector gases.

Carrier Gas:	He	= 30 mL/min
FPD Gases:	Air #1	= 80 mL/min
	Air #2	= 170 mL/min
	H_2	= 140 mL/min
FID Gases:	Air	= 300 mL/min
	H_2	= 30 mL/min

4.2.2 Columns

- Mercaptan and CS_2 Analysis

Stripper Column:	6' x 1/8" stainless steel, Porapak PS, acetone-washed, 80/100 mesh
Analytical Column:	6' x 1/8" stainless steel, Porapak PS, acetone-washed, 80/100 mesh

- COS Analysis

Stripper Column:	15' x 1/8" stainless steel, 30% TCEP + 5% H_3PO_4 on Chromasorb P, 80/100 mesh
Analytical Column:	6' x 1/8" nickel, Deactigel, 60/80 mesh

4.2.3 Calibration

NBS traceable permeation devices for carbonyl sulphide, methyl mercaptan, ethyl mercaptan, i-propyl mercaptan, n-propyl mercaptan, i-butyl mercaptan, and n-butyl mercaptan were purchased from GC Industries or Airwaves Electronics and used for calibration standards. A Linde FM 4575 mass flow controller was used to measure and control the flow of the diluent gas. The original permeation device and mass flow controller arrangement was used (see Figure 7 and Appendix 1).

The calibration calculations were based on the square root of peak height versus concentration in ppm on a volume/volume basis, using the external standard method of analysis. Both one point and multipoint calibration curves were developed.

The sample peak that was first thought to be i-butyl mercaptan was later determined to be s-butyl mercaptan. Thus, the results documented for s-butyl mercaptan are based on the calibration curve for i-butyl mercaptan. Although the detector response for these two compounds should be fairly similar, some error will be incorporated into the s-butyl mercaptan results.

4.2.4 Sampling

Gases: The procedure documented in the 1986 report, where the sample bomb was connected directly to the GC sampling loop, was followed.

Condensates: For safety reasons, a stainless steel valve was connected to one of the bomb valves. From this valve extended about 2" of 1/4" teflon tubing. A 1/4" stainless steel tubing connector was then used to make the union between the silanized glass trap and the teflon tubing. With a 1/4" to 1/8" stainless steel tubing connector, the outlet of the glass trap was connected to one port of the three-way valve. A luer lock fitting was used to join the 500-mL glass gas-tight syringe to the second port of the three-way valve. The third port of the three-way valve was either connected to a vacuum or left to the atmosphere to be used as a release valve. (See Figure 11, on page 20.)

Before flashing the condensate the system was evacuated by positioning the handle of the three-way valve so that both the glass trap and the syringe were connected to the vacuum. The stainless steel valve was then opened to evacuate the space between it and the bomb valve. Then the stainless steel valve was closed and the three-way valve was turned so that the vacuum line was eliminated from the system, leaving the sample bomb, glass trap, and syringe all connected.

With the stainless steel valve closed the bomb valve was opened and closed which allowed some of the condensate to enter the area between the two valves. Slowly the stainless steel valve was opened which released the trapped condensate into the flashing apparatus. The drop from bomb pressure to atmospheric pressure liberated a vapour fraction. The syringe plunger was pushed out to accommodate the volume of the vapour generated. The liquid that did not vaporize was collected in the bottom of the glass trap. The volume of vapour that was liberated was noted and the system was evacuated again. This entire process was repeated to remove any air that may have contaminated the sample.

The vacuum was then removed from the third port of the three-way valve; this port was then used as a release valve. The flashing procedure was then repeated until the syringe plunger had moved to about the 400-cc mark. The total volume of vapour liberated was summed and the liquid that had collected in the glass trap was weighed.

The 500-mL gas-tight syringe was connected directly to the GC gas sampling loop and the vapour fraction from the condensate was analysed using the procedure that had been used for the gas samples.

A 1-uL Hamilton syringe was used to inject 0.2 uL of the condensate liquid fraction.

4.2.5 GC Methods

The mercaptan and CS_2 analysis and the COS analysis both required three methods to be programmed into the data system: two single channel methods and a dual channel method. Each single channel method was built to monitor one detector, either the FID or FPD. The dual channel method was built to run both single channel methods simultaneously. In the dual channel method one of the single channel methods was identified as the primary method and the parameters listed in the GC control section of that method were followed. If there were any parameters in the GC control section of the secondary single channel method, they were ignored. The method that was built to monitor the FPD was designated as the primary single channel. The information from the FID was used only qualitatively to ensure adequate separation of the hydrocarbon compounds from the sulphur compounds.

Summary of GC Parameters

GC Parameters for Mercaptan and CS_2 Analysis

Porapak-Porapak Column Combination

Oven Temperature Program:	90°C for 8 min increase 5°C/min to 170°C hold 170°C for 4 min increase 20°C/min to 200°C hold 200°C for 23 min
Temperature Zones:	Injector A 210°C Injector B 60°C Detector 220°C
Relay Sequence:	backflush 0 to 4 min forward flow 4 to 22 min backflush after 22 min

GC Parameters for COS Analysis

30% TCEP + 5% H_3PO_4 - Deactigel Column Combination

Oven Temperature Program:	40°C for 5 min increase 10°C/min to 80°C hold 80°C for 10 min
Temperature Zones:	Injector A 210°C Injector B 60°C Detector 220°C
Relay Sequence:	forward flow 0 to 4 min backflush after 4 min

4.3 Results (1987-1988)

4.3.1 Calibration Coefficients and Curves

Table 9 lists the type of calibration curve employed, its coefficients (calibration factors) and the concentration of the calibration standard. The multipoint calibration lists the concentration of the highest standard whereas the one point calibration lists the concentration of the only standard.

TABLE 9 CALIBRATION DATA (1988)

Compound	Ret. Time (min)	Amount (ppm)	Coeff. 0	Coeff. 1	Detector Range	Calibration Curve
Carbonyl Sulphide	7.60	284.77	118 900	3 867	10 (-9)	LN
Carbonyl Sulphide	7.60	55.08	0.0	1 496	10 (-10)	OP
Methyl Mercaptan	10.50	1 053.0	-83 280	10 560	10 (-8)	LN
Methyl Mercaptan	10.50	105.3	59 000	977.6	10 (-10)	LN
Ethyl Mercaptan	13.00	1 073.7	56 040	10 560	10 (-8)	LN
Ethyl Mercaptan	13.00	94.95	44 190	927.6	10 (-10)	LN
i-Propyl Mercaptan	15.46	312.85	106 100	11 570	10 (-8)	LN
i-Propyl Mercaptan	15.46	83.99	34 220	1 046	10 (-10)	LN
n-Propyl Mercaptan	17.00	53.25	35 990	1 331	10 (-10)	LN
s-Butyl Mercaptan	19.60	118.25	93 500	1 084	10 (-10)	LN
n-Butyl Mercaptan	21.01	21.95	5 375	1 009	10 (-10)	LN

Note: LN Linear Non-zero Calibration: multipoint calibration using a best-fit straight line without forcing the use of the zero intercept.

OP One Point Calibration: a single point extrapolation through the zero intercept.

4.3.2 Results from the Lodgepole Samples

The results from the 1984 and 1987 Lodgepole samples are presented in Tables 10 through 21. All concentrations are in ppm on a volume/volume basis.

Tables 10, 13, 16, and 19 contain the results from the analyses of the condensate samples. These tables show the concentrations of sulphur compounds found in both the vapour and liquid fractions from the flashed condensates, as well as a total condensate sample concentration, which mathematically recombines the results from the vapour and liquid fractions.

Tables 11, 14, 17, and 20 contain the results from the analyses of the gas samples and re-documents the results from the corresponding condensate samples (on a total sample basis).

Tables 12, 15, 18, and 21 combine the results from the gas and condensate samples for a sulphur compound analysis on a total gas effluent basis.

TABLE 10 CONCENTRATION OF SULPHUR COMPOUNDS IN THE CONDENSATE SAMPLES RESULTS FOR THE 13-12-48-12W5 WELL (1984)

HIGH-PRESSURE SEPARATOR CONDENSATE SAMPLE (G4-784)

Compound	Vapour Fraction (ppm)	Liquid Fraction (ppm)	Total Sample (ppm)
Carbonyl Sulphide	181	LD	100
Methyl Mercaptan	287	101	199
Ethyl Mercaptan	222	230	226
i-Propyl Mercaptan	103	184	141
n-Propyl Mercaptan	40	129	82
s-Butyl Mercaptan	46	322	177
n-Butyl Mercaptan	7	55	30
Carbon Disulphide	LD	LD	LD

LOW-PRESSURE SEPARATOR CONDENSATE SAMPLE (G6-784)

Compound	Vapour Fraction (ppm)	Liquid Fraction (ppm)	Total Sample (ppm)
Carbonyl Sulphide	171	LD	12
Methyl Mercaptan	>1 053	661	> 688
Ethyl Mercaptan	>1 073	1 631	>1 593
i-Propyl Mercaptan	286	498	484
n-Propyl Mercaptan	69	227	216
s-Butyl Mercaptan	45	299	282
n-Butyl Mercaptan	7	54	51
Carbon Disulphide	LD	LD	LD

BOOT CONDENSATE SAMPLE (G5-784)

Compound	Vapour Fraction (ppm)	Liquid Fraction (ppm)	Total Sample (ppm)
Carbonyl Sulphide	no vapour fraction	LD	LD
Methyl Mercaptan	present	468	468
Ethyl Mercaptan		1 098	1 098
i-Propyl Mercaptan		360	360
n-Propyl Mercaptan		171	171
s-Butyl Mercaptan		279	279
n-Butyl Mercaptan		54	54
Carbon Disulphide		LD	LD

Note: LD Less than detection limit (5-10 ppm).

TABLE 11 CONCENTRATION OF SULPHUR COMPOUNDS ON A SAMPLE BASIS RESULTS FOR THE 13-12-48-12W5 WELL (1984)

Compound	High-Pressure Separator		Low-Pressure Separator		Boot	
	Gas (ppm)	Cond. (ppm)	Gas (ppm)	Cond. (ppm)	Gas (ppm)	Cond. (ppm)
Carbonyl Sulphide	43	100	76	12	153	LD
Methyl Mercaptan	40	199	D	> 688	D	468
Ethyl Mercaptan	35	226	D	>1 593	D	1 098
i-Propyl Mercaptan	30	141	D	484	D	360
n-Propyl Mercaptan	17	82	D	216	D	171
s-Butyl Mercaptan	19	177	D	282	D	279
n-Butyl Mercaptan	9	30	D	51	D	54
Carbon Disulphide	LD	LD	LD	LD	(4)	LD

Note: Indicates sulphur compounds were detected but not quantified. Except for the mercaptan concentrations in the high-pressure separator gas, the results for the gas samples are those documented in 1986.
LD Less than detection limit (5-10 ppm).

TABLE 12 RECOMBINATION FOR SULPHUR COMPOUND ANALYSIS ON A TOTAL GAS EFFLUENT BASIS RESULTS FOR THE 13-12-48-12W5 WELL (1984)

Compound	Gas (ppm)	Liquid (ppm)	Total Gas Effluent (ppm)
Carbonyl Sulphide	43	100	54
Methyl Mercaptan	40	199	71
Ethyl Mercaptan	35	226	72
i-Propyl Mercaptan	30	141	52
n-Propyl Mercaptan	17	82	30
s-Butyl Mercaptan	19	177	50
n-Butyl Mercaptan	9	30	13
Carbon Disulphide	LD	LD	LD

Note: LD Less than detection limit (5-10 ppm).

TABLE 13 CONCENTRATION OF SULPHUR COMPOUNDS IN THE CONDENSATE SAMPLES RESULTS FOR THE 10-2-48-12W5 WELL (1984)

HIGH-PRESSURE SEPARATOR CONDENSATE SAMPLE (P1-684)

Compound	Vapour Fraction (ppm)	Liquid Fraction (ppm)	Total Sample (ppm)
Carbonyl Sulphide	172	LD	83
Methyl Mercaptan	740	214	458
Ethyl Mercaptan	622	694	661
i-Propyl Mercaptan	148	312	235
n-Propyl Mercaptan	47	178	117
s-Butyl Mercaptan	41	329	195
n-Butyl Mercaptan	6	62	36
Carbon Disulphide	LD	LD	LD

LOW-PRESSURE SEPARATOR CONDENSATE SAMPLE (P2-684)

Compound	Vapour Fraction (ppm)	Liquid Fraction (ppm)	Total Sample (ppm)
Carbonyl Sulphide	245	LD	21
Methyl Mercaptan	>1 053	319	>378
Ethyl Mercaptan	797	819	817
i-Propyl Mercaptan	184	337	324
n-Propyl Mercaptan	54	182	172
s-Butyl Mercaptan	44	309	288
n-Butyl Mercaptan	6	55	51
Carbon Disulphide	LD	LD	LD

BOOT CONDENSATE SAMPLE (P3-684)

Compound	Vapour Fraction (ppm)	Liquid Fraction (ppm)	Total Sample (ppm)
Carbonyl Sulphide	no vapour fraction	LD	LD
Methyl Mercaptan	present	225	225
Ethyl Mercaptan		450	450
i-Propyl Mercaptan		234	234
n-Propyl Mercaptan		135	135
s-Butyl Mercaptan		324	324
n-Butyl Mercaptan		54	54
Carbon Disulphide		LD	LD

Note: LD Less than detection limit (5-10 ppm).

TABLE 14 CONCENTRATION OF SULPHUR COMPOUNDS ON A SAMPLE BASIS RESULTS FOR THE 10-2-48-12W5 WELL (1984)

Compound	High-Pressure Separator		Low-pressure Separator		Boot	
	Gas (ppm)	Cond. (ppm)	Gas (ppm)	Cond. (ppm)	Gas (ppm)	Cond. (ppm)
Carbonyl Sulphide	42	83	78	21	170	LD
Methyl Mercaptan	59	458	D	> 378	D	225
Ethyl Mercaptan	46	661	D	817	D	450
i-Propyl Mercaptan	41	235	D	324	D	234
n-Propyl Mercaptan	11	117	D	172	D	135
s-Butyl Mercaptan	17	195	D	288	D	324
n-Butyl Mercaptan	5	36	LD	51	D	54
Carbon Disulphide	LD	LD	8.2	LD	15.7	LD

Note: D Indicates sulphur compounds were detected but not quantified. Except for the mercaptan concentrations in the high-pressure separator gas, the results for the gas samples are those documented in 1986.
LD Less than detection limit (5-10 ppm).

TABLE 15 RECOMBINATION FOR SULPHUR COMPOUND ANALYSIS ON A TOTAL GAS EFFLUENT BASIS RESULTS FOR THE 10-2-48-12W5 WELL (1984)

Compound	Gas (ppm)	Liquid (ppm)	Total Gas Effluent (ppm)
Carbonyl Sulphide	42	83	50
Methyl Mercaptan	59	458	137
Ethyl Mercaptan	46	661	166
i-Propyl Mercaptan	41	235	79
n-Propyl Mercaptan	11	117	32
s-Butyl Mercaptan	17	195	52
n-Butyl Mercaptan	5	36	11
Carbon Disulphide	LD	LD	LD

Note: LD Less than detection limit (5-10 ppm).

TABLE 16 CONCENTRATION OF SULPHUR COMPOUNDS IN THE CONDENSATE SAMPLES (P5-1087) RESULTS FOR THE 13-12-48-12W5 WELL (1987, ANALYSED WITHIN 6 HOURS)

Compound	Vapour Fraction (ppm)	Liquid Fraction (ppm)	Total Sample (ppm)
Carbonyl Sulphide	152	LD	97
Methyl Mercaptan	61	LD	39
Ethyl Mercaptan	49	52	50
i-Propyl Mercaptan	47	96	65
n-Propyl Mercaptan	22	96	49
s-Butyl Mercaptan	34	278	122
n-Butyl Mercaptan	LD	52	19
Carbon Disulphide	LD	LD	LD

TABLE 17 CONCENTRATION OF SULPHUR COMPOUNDS ON A SAMPLE BASIS RESULTS FOR THE 13-12-48-12W5 WELL (1987, ANALYSED WITHIN 6 HOURS)

Compound	Wellhead Separator	
	Gas (G1-1087) (ppm)	Condensate (P5-1087) (ppm)
Carbonyl Sulphide	55	97
Methyl Mercaptan	17	39
Ethyl Mercaptan	11	50
i-Propyl Mercaptan	10	65
n-Propyl Mercaptan	LD	49
s-Butyl Mercaptan	LD	122
n-Butyl Mercaptan	LD	19
Carbon Disulphide	LD	LD

Note: LD Less than detection limit (5-10 ppm).

TABLE 18 RECOMBINATION FOR SULPHUR COMPOUND ANALYSIS ON A TOTAL GAS EFFLUENT BASIS RESULTS FOR THE 13-12-48-12W5 WELL (1987, ANALYSED WITHIN 6 HOURS)

Compound	Gas (ppm)	Liquid (ppm)	Total Gas Effluent (ppm)
Carbonyl Sulphide	55	97	67
Methyl Mercaptan	17	39	23
Ethyl Mercaptan	11	50	22
i-Propyl Mercaptan	10	65	26
n-Propyl Mercaptan	LD	49	14
s-Butyl Mercaptan	LD	122	35
n-Butyl Mercaptan	LD	19	6
Carbon Disulphide	LD	LD	LD

Note: LD Less than detection limit (5-10 ppm).

TABLE 19 CONCENTRATION OF SULPHUR COMPOUNDS IN THE CONDENSATE SAMPLE (P5-1087) RESULTS FOR THE 13-12-48-12W5 WELL (1987, ANALYSED AFTER 7 MONTHS)

Compound	Vapour Fraction (ppm)	Liquid Fraction (ppm)	Total Sample (ppm)
Carbonyl Sulphide	NA	NA	NA
Methyl Mercaptan	76	LD	57
Ethyl Mercaptan	66	70	67
i-Propyl Mercaptan	68	131	84
n-Propyl Mercaptan	28	96	45
s-Butyl Mercaptan	45	331	117
n-Butyl Mercaptan	4	61	18
Carbon Disulphide	LD	LD	LD

Note: LD Less than detection limit (5-10 ppm).
NA Not analysed.

TABLE 20 CONCENTRATION OF SULPHUR COMPOUNDS ON A SAMPLE BASIS RESULTS FOR THE 13-12-48-12W5 WELL (1987, ANALYSED AFTER 7 MONTHS)

Compound	Wellhead Separator	
	Gas (G1-1087) (ppm)	Condensate (P5-1087) (ppm)
Carbonyl Sulphide	NA	NA
Methyl Mercaptan	22	57
Ethyl Mercaptan	19	67
i-Propyl Mercaptan	20	84
n-Propyl Mercaptan	LD	45
s-Butyl Mercaptan	15	117
n-Butyl Mercaptan	LD	18
Carbon Disulphide	LD	LD

Note: LD Less than detection limit (5-10 ppm).
NA Not analysed

TABLE 21 RECOMBINATION FOR SULPHUR COMPOUND ANALYSIS ON A TOTAL GAS EFFLUENT BASIS RESULTS FOR THE 13-12-48-12W5 WELL (1987, ANALYSED AFTER 7 MONTHS)

Compound	Gas (ppm)	Liquid (ppm)	Total Gas Effluent (ppm)
Carbonyl Sulphide	NA	NA	NA
Methyl Mercaptan	22	57	32
Ethyl Mercaptan	19	67	33
i-Propyl Mercaptan	20	84	39
n-Propyl Mercaptan	LD	45	13
s-Butyl Mercaptan	15	117	45
n-Butyl Mercaptan	LD	18	5
Carbon Disulphide	LD	LD	LD

Note: LD Less than detection limit (5-10 ppm).
NA Not analysed.

5 DISCUSSION

As mentioned in subsection 3.2.4 of the Methodology 1987-1988 section, the condensate samples were flashed prior to analysis, which produced two phases: a vapour fraction and a liquid fraction. The vapour fraction was injected via the 250-uL gas sampling loop (as were the calibration standards) and thus, there was a direct sample to standard correlation. The liquid fraction was analysed by injecting 0.2 uL (syringe injection) of the liquid. A correction factor, which incorporated the condensate vaporization volume and as equivalent volume of 0.2 uL of the liquid, was applied to adjust the 0.2-uL liquid analysis to the 250-uL gas standard. Then the concentrations of the various sulphur compounds from both the vapour and the liquid fractions were combined for a total condensate sample concentration.

To obtain an analysis on a total gas effluent basis, the results from the gas samples and the condensate samples were recombined using the well's production rate data. Appendix 3 contains the raw results, physical data (flashing weights and volumes, densities, production rates), and calculations.

The results from the condensate samples (Tables 10, 13, and 16) indicate that COS was predominantly in the vapour fraction, methyl mercaptan was more prominent in the vapour fraction than in the liquid fraction, ethyl mercaptan was found in both the vapour and the liquid fractions, while the propyl and butyl mercaptans became more evident in the liquid fraction.

The chromatograms of the condensates (both the vapour and the liquid fractions) indicated that these samples also contained sulphur compounds that were less volatile or higher in molecular weight than n-butyl mercaptan. These compounds were more prominent in the liquid fraction than in the vapour fraction (see Figures 14 and 15).

The mercaptan concentrations found in the 1984 low-pressure separator and boot condensates were generally higher than those found in the high-pressure separator condensates (Tables 10 and 13). As well, the COS concentration in the 1984 gas samples increased as the separator pressure decreased (Tables 11 and 14). The COS and CS_2 results for the gas samples (Tables 11 and 14) are those from the 1986 analyses. The high-pressure separator gases were quantitatively analysed for their mercaptan content in 1988. The low-pressure separator and boot gas samples contained insufficient sample for a mercaptan analysis; their mercaptan results could not be compared with the COS results to determine if a similar trend existed. Possibly the lower production rates of the low-pressure separator and boot (as compared with that of the high-pressure separator) may balance out the higher mercaptan content found in the condensates. Another possibility is that with time and pressure reduction, reactions were occurring within the sample containers that produced mercaptans and COS.[19,20]

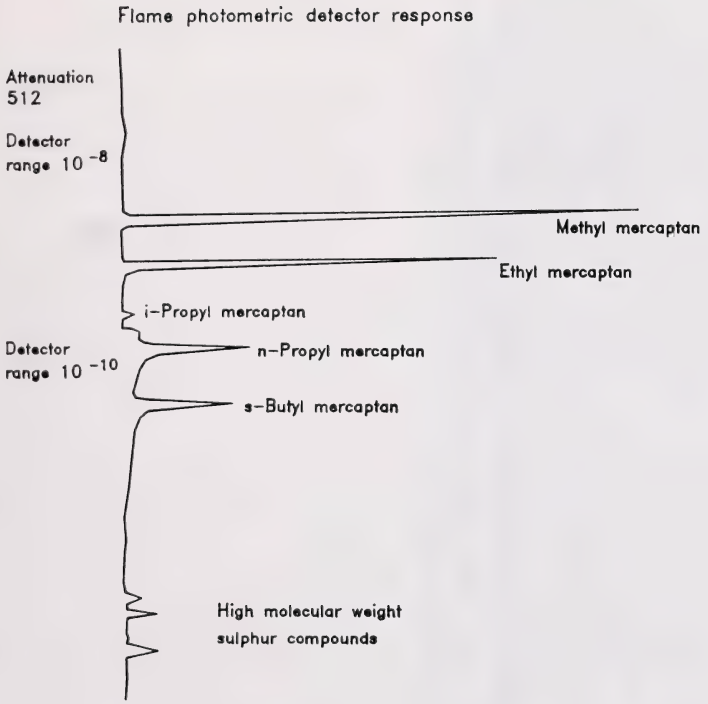


FIGURE 14: CHROMATOGRAM OF THE GAS FRACTION FROM A CONDENSATE SAMPLE

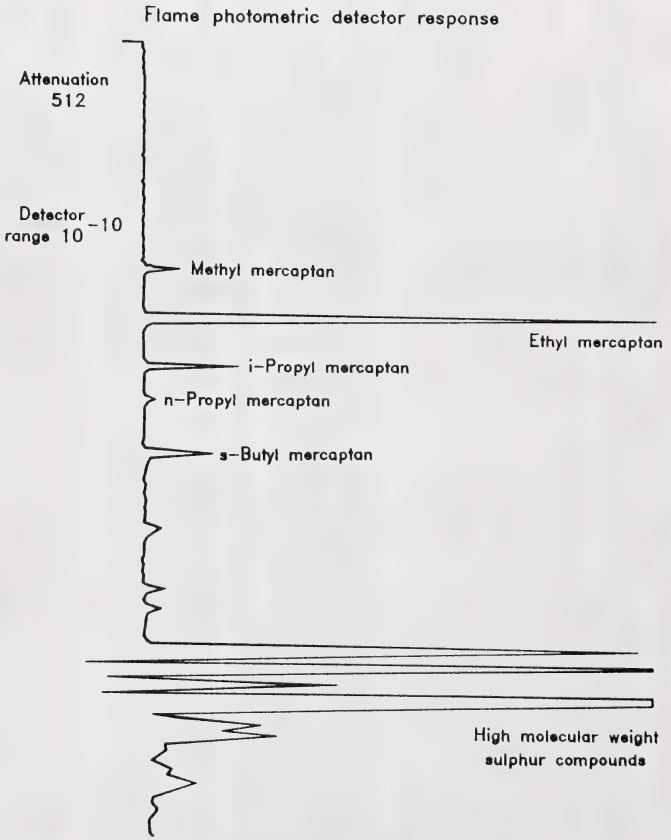


FIGURE 15: CHROMATOGRAM OF THE LIQUID FRACTION FROM A CONDENSATE SAMPLE

In the 1986 analysis, CS_2 was detected in the gases and the condensates from the low-pressure separator, boot, and stock tank originating from the 10-2 well and in the gas from the boot and the condensates (high-pressure separator, low-pressure separator, and boot) from the 13-12 well. However, in the 1988 analysis, CS_2 was not detected in any of the condensates from either well. It is possible that with time and with pressure reduction within the sample containers resulting from the withdrawal of sample from the containers, the composition had changed. The highest concentration for CS documented in 1986 was only 18 ppm and that was found in the gas sample taken from the 10-2 well stock tank. This particular sample was below gauge pressure when it was received.

A gas and a condensate sample were taken from the wellhead separator of the 13-12 well in late October 1987. These samples were analysed for their mercaptan content within 6 hours and their COS content within 5 days. The mercaptan analysis was repeated 7 months later.

The COS and mercaptan results from the condensate analysis gave a concentration ratio of the vapour to liquid fraction that was similar to the 1984 condensates (Table 16). The condensate contained 97 ppm COS and fairly low concentrations of the mercaptans: s-butyl mercaptan was 122 ppm while the other mercaptans were 65 ppm and lower, while CS_2 was not detected.

The 1987 gas sample contained 55 ppm COS and low levels (<20 ppm) of methyl, ethyl, and i-propyl mercaptan (Table 17). The mercaptan analysis, which was repeated 7 months later, indicated that the concentrations of methyl, ethyl, and i-propyl mercaptan within the gas sample had increased slightly and a quantifiable peak for s-butyl mercaptan (15 ppm) had appeared. The methyl, ethyl, and i-propyl mercaptan concentrations also increased in the condensate sample, while the n-propyl and butyl mercaptan concentrations remained fairly constant (Table 20).

When the gas and condensate results were mathematically recombined for an analysis on a total effluent basis, the concentrations of the 7-month analysis had increased by approximately 30% as compared to the 6-day analysis (Tables 18 and 21). Separate experiments should be set up to investigate the changes of sulphur compound concentration with time.

In order to compare the 13-12 well's 1987 samples with the 1984 samples, the 1984 gas and condensate results also had to be recombined for an analysis on a total gas effluent basis. The 1984 samples were from a series of separators (high-pressure, low-pressure, and boot) whereas the 1987 samples were from a single stage separator at the wellhead. To calculate the 1984 results on a reservoir basis it was assumed that the 1984 high-pressure separator was comparable to the 1987 wellhead separator. Thus, the gas and condensate results from only the high-pressure separator were recombined for the 1984 reservoir analysis (Table 12).

The production rate data for the 1984 samples were taken from an AOFP test that was performed in June of 1984 (information provided by the ERCB Gas Department). The October 1987 gas and liquid production rates for the 13-12 well were provided by the ERCB Drayton Valley Field Office. The production rates used for the 1984 samples were 267.0 thousand cubic metres per day (10^3 m^3/d) for the gas fraction and 65.0 x 10^3 m^3/d for the liquid fraction, while the production rates used for the 1987 samples were 159.7 x 10^3 m^3/d for the gas fraction and 65.5 x 10^3 m^3/d for the liquid fraction.

The 1984 mercaptan concentrations in the 13-12 well were approximately double those of the 1987 concentrations, whereas the COS concentrations were fairly similar. See Table 22 for a tabulation of the total gas effluent analyses. The 10-2 well contained almost double the 13-12 well's 1984 concentrations of methyl and ethyl mercaptan, whereas the concentrations of COS and the propyl and butyl mercaptans were fairly similar.

Considering the 1984 condensate samples were almost 4 years old when they were analysed, the 1984 and 1987 total gas effluent analyses for the 13-12 well are comparable. The question of changes in the samples with time remains to be investigated. Until this question is settled, the time interval between sampling and analysis should be minimized for future analysis.

Some sources of error that became obvious during this project:

- at the time of sampling, production rate data along with pressure and temperature must be recorded

- calibration standards, although expensive and possibly difficult to obtain, require an accuracy check

- accurate physical data (density and molecular weight) and flashing data are required before the concentrations of sulphur compounds on a sample basis and a total gas effluent basis can be calculated

The results documented so far are on a sample or total gas effluent basis. When the 13-12 well was out of control, how do these results relate to the relative concentrations a person or animal may have been exposed to in an area where the H_2S concentration had reached the evacuation level of 20 ppm?

Since this reservoir contained approximately 25% H_2S, the exposure concentration calculation was based on an H_2S ratio of 250 000 ppm to 20 ppm. This calculation assumes ultimate vaporization of all reservoir fluids except water and thus the exposure concentrations are purely theoretical.

TABLE 22 TABULATION OF THE SULPHUR COMPOUND ANALYSIS ON A TOTAL GAS EFFLUENT BASIS FOR THE 1984 AND 1987 SAMPLES

Compound	13-12 Well 1984 (ppm)	10-2 Well 1984 (ppm)	13-12 Well 1987 (6 hours, ppm)	13-12 Well 1987 (7 months, ppm)
Carbonyl Sulphide	54	50	67	NA
Methyl Mercaptan	71	137	23	32
Ethyl Mercaptan	72	166	22	33
i-Propyl Mercaptan	52	79	26	39
n-Propyl Mercaptan	30	32	14	13
s-Butyl Mercaptan	50	52	35	45
n-Butyl Mercaptan	13	11	6	5
Carbon Disulphide	LD	LD	LD	LD

Note: LD Less than detection limit (5-10 ppm).
NA Not analysed.

Table 23 contains the relative exposure concentrations based on the 1984 total gas effluent concentrations for the 13-12 well (Table 12), as well as some threshold odour concentrations. The threshold odour concentrations, which vary from person to person, were provided by Dr. Shekar Viswanathan of Clayton Environmental Consultants. The highest calculated exposure concentration was 0.005 8 ppm and was for ethyl mercaptan. The threshold odour data, although subjective, indicates that the calculated exposure concentrations were within ranges that some people may easily smell.

TABLE 23 EXPOSURE CONCENTRATIONS RELATIVE TO THE 20 ppm H_2S EVACUATION CONCENTRATION AND THRESHOLD ODOUR CONCENTRATIONS

Compound	Total Gas Effluent Concentration (ppm)	Relative Exposure Concentration (ppm)	*Threshold Odour Concentrations (ppm)
Carbonyl Sulphide	54	0.004 3	no data
Carbon Disulphide	LD	-	0.016 to 0.021
Methyl Mercaptan	71	0.005 7	0.000 000 2 to 0.41
Ethyl Mercaptan			0.000 098 to 0.005
i-Propyl Mercaptan	72	0.005 8	no data
n-Propyl Mercaptan	52	0.004 2	0.000 06 to 0.02
s-Butyl Mercaptan	30	0.002 4	no data
n-Butyl Mercaptan	50	0.004 0	0.000 099
	13	0.001 0	

Note: LD Less than detection limit (5-10 ppm).
* Data provided by Dr. Shekar Viswanathan of Clayton Environmental

6 CONCLUSION

In compliance with Recommendation 7 in the Hazard to Human Health section of the Lodgepole Blowout Report (D 84-9), the ERCB Chemical Research Laboratory developed a method to quantitatively analyse the sulphur compounds within a sour gas reservoir.

The results documented in this report are associated with an error of approximately 30%. This may be due to possible chemical reactions that occurred within the sample containers over the 3.5 years that elapsed between the sampling and the analysis of the 1984 Lodgepole samples and to the inaccuracy of such data as the reservoir production rates, the condensate vaporization volume, the flashed gas volume, and the average molecular weight assigned to the liquid. Additional work in the areas of sample degradation with time and physical properties of sulphur compounds (such as molar liquid volumes) should be done.

The sulphur compounds, other than H_2S and SO_2, identified in the gas samples and vapour fractions from the condensates produced by the Lodgepole 10-2 and 13-12 wells were COS and the methyl, ethyl, propyl, and butyl mercaptans. The mercaptan concentrations in the gas samples and vapour fractions ranged from methyl mercaptan being the highest to n-butyl mercaptan being the lowest. The liquid fractions from the condensates also contained the mercaptans but the concentration ratio for a mercaptan increased in the liquid fraction (as compared with the vapour fraction) as the mercaptan became less volatile. COS was not detected in the liquid fraction from the condensates, but significant amounts of higher molecular weight sulphur compounds (possibly aromatic) were detected.

The Lodgepole portion of the sulphur compounds in natural gas study has been completed. The methodology developed and information acquired in the areas of instrumentation, sample handling (both field and laboratory), and data manipulation will contribute to more accurate determinations in the second part of this study. The second part involves sampling and analysing other reservoirs for characterization in regard to sulphur and hydrocarbon compounds.

APPENDIX 1 PERMEATION DEVICES

The permeation device is designed to continuously release a fixed rate of material at a given temperature. The released material is mixed with a diluent gas, such as nitrogen, to give a calibration mixture of a known concentration in ppm by volume. To generate a desired concentration the diluent gas, which is set at a known flow-rate, is passed through one side of a tee assembly while the device is connected to the middle of the tee and the calibration mixture is available at the other side of the tee.

The concentration of the compound is calculated with the following formula:

$$C = \frac{K \times P}{F}$$

where C = concentration in ppm
K = a constant (specific for each compound)
F = diluent gas flow-rate in mL/min
P = permeation rate of the device in nanograms per minute at the experimental temperature (Each permeation device comes with a calibration graph of permeation rate versus temperature.)

The manufacturer's permeation rate should be checked. This can be done by inserting the permeation device in a water bath or oven that is maintained at a constant temperature and monitoring its weight loss (in nanograms) over a period of time (in minutes). The temperature of the bath or oven should be at the temperature the manufacturer used to certify the permeation rate, usually 20°C or 25°C.

SPECIFICATIONS FOR THE PERMEATION DEVICES

Compound	Constant (K)	Permeation Rate (ng/min @ 25°C)	Manufacturer
Carbon Disulphide	0.321	740	GC Industries
Carbonyl Sulphide	0.406	5 500	GC Industries
Carbonyl Sulphide	0.406	16 280	Airwaves Electronics
Methyl Mercaptan	0.509	860	GC Industries
Methyl Mercaptan	0.509	41 379	Airwaves Electronics
Ethyl Mercaptan	0.394	34 650	Airwaves Electronics
i-Propyl Mercaptan	0.321	38 985	Airwaves Electronics
n-Propyl Mercaptan	0.321	19 906	Airwaves Electronics
i-Butyl Mercaptan	0.271	4 800	Airwaves Electronics
n-Butyl Mercaptan	0.271	810	GC Industries

MOLECULAR WEIGHT AND DENSITY OF SULPHUR COMPOUNDS

Compound	UPAC Name	Molecular Weight (g/mol)	Density (g/mL)
Hydrogen Sulphide		34.08	
Carbonyl Sulphide		60.07	
Methyl Mercaptan	Methanethiol	48.11	
Ethyl Mercaptan	Ethanethiol	62.13	0.839 1
Dimethyl Sulphide		62.13	0.848 3
Carbon Disulphide		76.14	1.263 2
i-Propyl Mercaptan	2-Propanethiol	76.17	0.814 3
t-Butyl Mercaptan	2-Methyl-2-Propanethiol	90.19	0.800 2
n-Propyl Mercaptan	1-Propanethiol	76.17	0.841 1
s-Butyl Mercaptan	2-Butanethiol (1-Methyl-1-Propanethiol)	90.19	0.829 9
i-Butyl Mercaptan	2-Methyl-1-Propanethiol	90.19	0.833 9
n-Butyl Mercaptan	1-Butanethiol	90.19	0.833 7
Dimethyl Disulphide		94.20	1.062 5

APPENDIX 2 CALIBRATION OF THE FPD THROUGH THE VARIAN DS 651 CHROMATOGRAPHY DATA SYSTEM

Both the one point (OP) and multipoint calibrations were used in the result computations. If the concentration of a particular compound was fairly consistent throughout the samples, then only an OP calibration was used. However, if the concentration of a particular compound varied throughout the samples, then a multipoint calibration was used (the standards would range in concentration to envelope the concentrations contained in the samples).

The OP calibration is based on a single point extrapolation through the zero intercept; the detector response must be linear. Therefore, when calibrating an FPD using OP calibration, the square root of the peak height must be used for the data computation and the concentration of the calibration standard must be similar to that of the sample. The calibration factor for an OP external standard calculation is derived by the following formula:

$$calibration\,factor = \frac{standard\,concentration}{peak\,height\,of\,standard}$$

The concentration of the sample for an external standard calculation is derived by the following formula during an analysis run:

$$concentration\,sample\,component = peak\,height\,(sample) \times calibration\,factor$$

The data system can also perform five types of multipoint calibration during external standard calculations. Only two types of multipoint calibrations were used: linear non-zero intercept (LN) and second order non-zero intercept (SN).

The LN type of calibration draws a "best fit" straight line through the calibration data points without forcing the use of the zero intercept. Two or more calibration points (standard concentrations) must be used and with the FPD the square root of peak height must be used. The LN calibration is based on the following general polynomial equation:

$$Y = A + Bx$$

The SN type of calibration draws a second order curve through the data points produced by a series of calibrations without forcing the use of the zero intercept. Three or more calibration points (standard concentrations) must be used. Since this calibration does not require a linear response, peak area or peak height may be used with the FPD.

The SN calibration is based on the following general polynomial equation:

$$Y = A + Bx + Cx^2$$

Whenever possible the samples were analysed using both LN and SN multipoint calibration. The results from the SN calibration were used only to compare with those from the LN calibration. The results from the LN or OP calibration are documented in this report.

APPENDIX 3 CALCULATIONS AND DATA

To obtain meaningful results the concentrations computed by the chromatography data system had to be manipulated in the following ways:

- the results from the 0.2-uL liquid analysis were adjusted to a 250-uL gas standard
- the results from the vapour and liquid fractions of the condensate samples were combined to obtain an analysis on a sample basis
- the results from the gas and condensate samples were recombined to obtain an analysis on a total gas effluent basis

The following calculations were provided by the ERCB Gas Department.

1 Correction of 0.2-uL Liquid Results

First, the condensate vaporization volume was determined from the density and molecular weight of the flashed liquid and from the molar volume of a gas. The molecular weight was taken from a 16 July 1984 stock tank liquid test of the Lodgepole well.

Results from Condensate Sample P1-684

$$V = \frac{1.0 m^3 x 792.5 kg/m^3 x 23.645 m^3/kg\,mol}{134.17 kg/kg\,mol} = 140 m^3(gas)/m^3(liquid)$$

Where: V = condensate vaporization volume
792.5 kg/m^3 = density of liquid (measured)
23.645 m^3/kg mol = molar volume for a gas
134.17 kg/kg mol = molecular weight of liquid

Then the gas equivalent volume of 0.2 uL liquid was determined.

Gas Equivalent Volume = 0.2 uL x 140 m^3/m^3 = 28 uL (gas)

Then the correction factor for the liquid analysis was determined.

$$Correction\,factor = \frac{250 uL}{28 uL} = 8.9$$

(The results from the liquid fraction for Sample P1-684 were multiplied by 8.9.)

2 Combine Liquid and Vapour Fractions to Obtain an Analysis on a Sample Basis

In this calculation the weight of the flashed liquid was converted to a liquid volume and then to an equivalent gas volume. Then the concentrations in the vapour fraction and liquid fraction (corrected values) were converted to a volume (cc) so that they could be added and then back-calculated to obtain a concentration in the total sample.

Results from Sample P1-684

Condensate Flashing Data:

Volume flashed gas	=	650 cc
Weight flashed liquid	=	4.231 8 g
Density flashed liquid	=	0.729 5 g/cc

$$Liquid\,Volume = \frac{4.2318\,g}{0.79255\,g/cc} = 5.3398\,cc$$

Liquid's Gas Volume = 5.339 8 cc x 140 m^3/m^3 = 748 cc

Sample's Total Gas Volume = 650 cc + 748 cc = 1 398 cc

Methyl Mercaptan Concentration for Sample P1-684

- from data system

  740 ppm in vapour fraction
  24 ppm x 8.9 = 213.6 ppm in liquid fraction

converting ppm in vapour fraction to cc

$$650\,cc \times \frac{740\,ppm}{1000000} = 0.4810\,cc$$

converting ppm in liquid fraction to cc

$$748\,cc \times \frac{213.6\,ppm}{1000000} = 0.1598\,cc$$

Total cc of methyl mercaptan in Sample P1-684

0.4 810 cc + 0.159 8 cc = 0.640 8 cc

converting cc of methyl mercaptan to ppm

$$\frac{0.6408\,cc}{1398\,cc} \times 1000000 = 458\,ppm$$

3 Combine Gas and Condensate Results to Obtain an Analysis on a Total Gas Effluent Basis

In this calculation the concentrations in the gas and condensate samples were converted to a rate using the well's production rate data. The two rates for a compound were then added to obtain a total rate, which was back-calculated to obtain a concentration on a total gas effluent basis. The calculations for the 1984 samples were based on the rate data from the 1984 AOFP test and only on the results from the gas and condensate samples taken from the high-pressure separator. The calculations for the 1987 samples were based on the well's October 1987 production rates and on the results from the gas and condensate samples taken from the wellhead separator.

Production Rate Data for Well

High-stage gas	267.0×10^3 m^3/d	
Low-stage gas	31.9×10^3 m^3/d	
		65.0×10^3 m^3/d
Gas equivalent of condensate	33.1×10^3 m^3/d	
Total production	332.0×10^3 m^3/d	

Methyl Mercaptan Concentration in the Lodgepole 10-2 Well

High-pressure separator gas (G1-684) = 59 ppm

High-pressure separator liquid (P1-684) = 458 ppm

Concentration of methyl mercaptan in gas (m^3/d)

$$\frac{50 ppm}{1000000} \times 267000 m^3/d = 15.753 m^3/d$$

Concentration of methyl mercaptan in condensate (m^3/d)

$$\frac{458 ppm}{1000000} \times 65000 m^3/d = 29.770 m^3/d$$

Concentration of methyl mercaptan in reservoir (m^3/d)

$$15.753 m^3/d + 29.770 m^3/d = 45.523 m^3/d$$

Concentration of methyl mercaptan in reservoir (ppm)

$$\frac{45.523 m^3/d}{332000 m^3/d} \times 1000000 = 137 ppm$$

4 Comments on the Calculations

The calculations presented are not rigorously correct. For a more accurate condensate vaporization volume determination for the condensates, a molecular weight determination, as well as a density measurement, should have been performed on each flashed liquid. As well, the volumes of the flashed vapour from the condensates should have been corrected to standard temperature and pressure. Also, the rate data taken from an AOFP test done in June 1984 may not be the rates at which the 10-12 well and the 13-12 well were producing when they were sampled in 1984. This may greatly affect the results for the 1984 Lodgepole samples.

RAW DATA AND RESULTS

RECOMBINATION FOR ANALYSIS ON A TOTAL GAS EFFLUENT BASIS
WELL: 10-2-48-12W5 (1984)
PRODUCTION RATE DATA: 1984 AOFP TEST

High-stage rate gas	267.0 x 10^3 m^3/d
Low-stage rate gas	31.9 x 10^3 m^3/d
Gas equivalent of condensate	33.1 x 10^3 m^3/d
Total production	332.0 x 10^3 m^3/d

Compound	Gas		Liquid		Total Gas Effluent	
	ppm	m^3/d	ppm	m^3/d	ppm	m^3/d
Carbonyl Sulphide	42	11.214	83	5.395	50	16.609
Methyl Mercaptan	59	15.753	458	29.770	137	45.523
Ethyl Mercaptan	46	12.282	661	42.965	166	55.247
i-Propyl Mercaptan	41	10.947	235	15.275	79	26.222
n-Propyl Mercaptan	11	2.937	117	7.605	32	10.542
s-Butyl Mercaptan	17	4.539	195	12.675	52	17.214
n-Butyl Mercaptan	5	1.335	36	2.340	11	3.675
Carbon Disulphide	LD	-	LD	-	LD	-

Note: LD Less than detection limit (5-10 ppm).

CONCENTRATION OF SULPHUR COMPOUNDS ON A SAMPLE BASIS
WELL: 10-2-48-12W5 (1984)

Compound	High-pressure Separator		Low-pressure Separator		Boot	
	Gas (ppm)	Cond. (ppm)	Gas (ppm)	Cond. (ppm)	Gas (ppm)	Cond. (ppm)
Carbonyl Sulphide	42	83	78	21	170	LD
Methyl Mercaptan	59	458	D	>378	D	225
Ethyl Mercaptan	46	661	D	817	D	450
i-Propyl Mercaptan	41	235	D	324	D	234
n-Propyl Mercaptan	11	117	D	172	D	135
s-Butyl Mercaptan	17	195	D	288	D	324
n-Butyl Mercaptan	5	36	LD	51	LD	54
Carbon Disulphide	LD	LD	8.2	LD	15.7	LD

Note: D Indicates sulphur compounds were detected but not quantified.
Except for the mercaptan concentrations in the high-pressure separator gas, the results for the gas samples are those documented in 1986.
LD Less than detection limit (5-10 ppm).

LODGEPOLE STUDY

GAS ANALYSIS

SAMPLE NUMBER G1-684

Compound	Concentration (ppm)
Carbonyl Sulphide	42
Methyl Mercaptan	59
Ethyl Mercaptan	46
i-Propyl Mercaptan	41
n-Propyl Mercaptan	11
s-Butyl Mercaptan	17
n-Butyl Mercaptan	5

LODGEPOLE STUDY
CONDENSATE ANALYSIS

SAMPLE NUMBER P1-684 (High-pressure Separator)

FLASHING AND GAS VOLUME DATA

	Mercaptan Analysis	COS Analysis
Volume Flashed Gas, cc	650	550
Weight Flashed Liquid, g	4.231 8	3.351 4
Density Liquid, g/cc	0.792 5	0.789 4
Condensate Vaporization Volume, m^3/m^3	140	139
Correction Factor (Liquid Analysis)	8.9	8.99
Liquid Volume, cc	5.339 8	4.245 5
Liquid's Gas Volume, cc	748	590
Total Sample Gas Volume, cc	1 398	1 140

ANALYSIS DATA

Compound	Vapour Fraction		Liquid Fraction			Total Sample	
	ppm	cc	ppm (1)	ppm (2)	cc	ppm	cc
Carbonyl Sulphide	172	0.094 6	LD	-	-	83	0.094 6
Methyl Mercaptan	740	0.481	24	213.6	0.159 8	458	0.640 8
Ethyl Mercaptan	622	0.404 3	78	694.2	0.519 3	661	0.923 6
i-Propyl Mercaptan	148	0.096 2	35	311.5	0.233	235	0.329 2
n-Propyl Mercaptan	47	0.030 6	20	178	0.133 1	117	0.163 7
s-Butyl Mercaptan	41	0.026 7	37	329	0.246 1	195	0.272 8
n-Butyl Mercaptan	6	0.003 9	7	62	0.046 4	36	0.050 3

Note: LD Less than detection limit (5-10 ppm).
(1) not corrected.
(2) corrected.

LODGEPOLE STUDY
CONDENSATE ANALYSIS

SAMPLE NUMBER P2-684
(Low-pressure Separator)
FLASHING AND GAS VOLUME DATA

	Mercaptan Analysis	C6OS Analysis
Volume Flashed Gas, cc	420	540
Weight Flashed Liquid, g	26.895 8	33.009 7
Density Liquid, g/cc	0.775 2	0.784 7
Condensate Vaporization Volume, m^3/m^3	137.0	138
Correction Factor (Liquid Analysis)	9.1	9.06
Liquid Volume, cc	34.695 3	42.066 6
Liquid's Gas Volume, cc	4 753	5 805
Total Sample Gas Volume, cc	5 173	6 345

ANALYSIS DATA

Compound	Vapour Fraction		Liquid Fraction			Total Sample	
	ppm	cc	ppm (1)	ppm (2)	cc	ppm	cc
Carbonyl Sulphide	245	0.132 3	LD	-	-	21	0.132 3
Methyl Mercaptan	>1 053	0.442 3	35	318.5	1.513 8	378	1.956 1
Ethyl Mercaptan	797	0.334 7	90	819	3.892 7	817	4.227 4
i-Propyl Mercaptan	184	0.077 3	37	336.7	1.600 3	324	1.677 6
n-Propyl Mercaptan	54	0.022 7	20	182	0.865 0	172	0.887 7
s-Butyl Mercaptan	44	0.018 5	34	309.4	1.470 6	288	1.489 1
n-Butyl Mercaptan	6	0.002 5	6	54.6	0.259 5	51	0.262 0

Note: LD Less than detection limited (5-10 ppm).
(1) Not corrected.
(2) Corrected.

LODGEPOLE STUDY
CONDENSATE ANALYSIS

SAMPLE NUMBER P3-684
(Boot; liquid only, no vapour fraction*)

FLASHING AND GAS VOLUME DATA

	Mercaptan Analysis	COS Analysis
Volume Flashed Gas	*	*
Weight Flashed Liquid		
Density Liquid, g/cc	0.785 7	0.785 7
Condensate Vaporization Volume, m^3/m^3	138.5	138.5
Correction Factor (Liquid Analysis)	9	9
Liquid Volume		
Liquid's Gas Volume		
Total Sample Gas Volume		

ANALYSIS DATA

Compound	Vapour Fraction		Liquid Fraction			Total Sample	
	ppm	cc	ppm (1)	ppm (2)	cc	ppm	cc
Carbonyl Sulphide	*	*	LD	-		-	
Methyl Mercaptan	*	*	25	225		225	
Ethyl Mercaptan	*	*	50	450		450	
i-Propyl Mercaptan	*	*	26	234		234	
n-Propyl Mercaptan	*	*	15	135		135	
s-Butyl Mercaptan	*	*	36	324		324	
n-Butyl Mercaptan	*	*	6	54		54	

Note: LD Less than detection limited (5-10 ppm).
(1) Not corrected.
(2) Corrected.

RECOMBINATION FOR ANALYSIS ON A TOTAL GAS EFFLUENT BASIS
WELL: 13-12-48-12W5 (1984)
PRODUCTION RATE DATA: 1984 AOFP TEST

High-stage rate gas	267.0 x 10^3 m^3/d
Low-stage rate gas	31.9 x 10^3 m^3/d
Gas equivalent of condensate	33.1 x 10^3 m^3/d
Total production	332.0 x 10^3 m^3/d

Compound	Gas		Liquid		Total Gas Effluent	
	ppm	m^3/d	ppm	m^3/d	ppm	m^3/d
Carbonyl Sulphide	43	11.481	100	6.500	54	17.981
Methyl Mercaptan	40	10.68	199	12.935	71	23.615
Ethyl Mercaptan	35	9.345	226	14.690	72	24.035
i-Propyl Mercaptan	30	8.01	141	9.165	52	17.175
n-Propyl Mercaptan	17	4.539	82	5.330	30	9.869
s-Butyl Mercaptan	19	5.073	177	11.505	50	16.578
n-Butyl Mercaptan	9	2.403	30	1.950	13	4.353
Carbon Disulphide	LD	-	LD	-	LD	-

Note: LD Less than detection limit (5-10 ppm).

CONCENTRATION OF SULPHUR COMPOUNDS ON A SAMPLE BASIS
WELL: 13-12-48-12W5 (1984)

Compound	High-Pressure Separator		Low-pressure Separator		Boot	
	Gas (ppm)	Cond. (ppm)	Gas (ppm)	Cond. (ppm)	Gas (ppm)	Cond. (ppm)
Carbonyl Sulphide	43	100	76	12	153	LD
Methyl Mercaptan	40	199	D	>688	D	468
Ethyl Mercaptan	35	226	D	>1 593	D	1 098
i-Propyl Mercaptan	30	141	D	484	D	360
n-Propyl Mercaptan	17	82	D	216	D	171
s-Butyl Mercaptan	19	177	D	282	D	279
n-Butyl Mercaptan	9	30	D	51	D	54
Carbon Disulphide	LD	LD	LD	LD	LD	LD

Note: D Indicates sulphur compounds were detected but not quantified.
Except for the mercaptan concentrations in the high-pressure separator gas, the results for the gas samples are those documented in 1986.
LD Less than detection limit (5-10 ppm).

LODGEPOLE STUDY
GAS ANALYSIS

SAMPLE NUMBER G1-784

Compound	Concentration (ppm)
Carbonyl Sulphide	43
Methyl Mercaptan	40
Ethyl Mercaptan	35
i-Propyl Mercaptan	30
n-Propyl Mercaptan	17
s-Butyl Mercaptan	19
n-Butyl Mercaptan	9

LODGEPOLE STUDY
CONDENSATE ANALYSIS

SAMPLE NUMBER G4-784 (High-pressure Separator)

FLASHING AND GAS VOLUME DATA

	Mercaptan Analysis	COS Analysis
Volume Flashed Gas, cc	600	530
Weight Flashed Liquid, g	3.055 7	2.462 7
Density Liquid, g/cc	0.771 2	0.790 2
Condensate Vaporization Volume, m^3/m^3	136	139
Correction Factor (Liquid Analysis)	9.2	8.99
Liquid Volume, cc	3.962 3	3 116 6
Liquid's Gas Volume, cc	539	433
Total Sample Gas Volume, cc	1 139	963

ANALYSIS DATA

Compound	Vapour Fraction		Liquid Fraction			Total Sample	
	ppm	cc	ppm (1)	ppm (2)	cc	ppm	cc
Carbonyl Sulphide	181	0.095 9	LD	-	-	100	0.095 9
Methyl Mercaptan	287	0.172 2	11	101.2	0.054 5	199	0.226 7
Ethyl Mercaptan	222	0.133 2	25	230	0.124	226	0.257 2
i-Propyl Mercaptan	103	0.061 8	20	184	0.099 2	141	0.161
n-Propyl Mercaptan	40	0.024	14	128.8	0.069 4	82	0.0934
s-Butyl Mercaptan	46	0.027 6	35	322	0.173 6	177	0.201 2
n-Butyl Mercaptan	7	0.004 2	6	55.2	0.029 8	30	0.034 0

Note: LD Less than detection limit (5-10 ppm).
(1) Not corrected.
(2) Corrected.

LODGEPOLE STUDY
CONDENSATE ANALYSIS

SAMPLE NUMBER G6-784 (Low-pressure Separator)

FLASHING AND GAS VOLUME DATA

	Mercaptan Analysis	COS Analysis
Volume Flashed Gas, cc	420	480
Weight Flashed Liquid, g	33.021 5	36.898 6
Density Liquid, g/cc	0.783 6	0.783 0
Condensate Vaporization Volume, m^3/m^3	138	138
Correction Factor (Liquid Analysis)	9.06	9.06
Liquid Volume, cc	42.140 8	47.124 6
Liquid's Gas Volume, cc	5 815	6 503
Total Sample Gas Volume, cc	6 235	6 983

ANALYSIS DATA

Compound	Vapour Fraction		Liquid Fraction			Total Sample	
	ppm	cc	ppm (1)	ppm (2)	cc	ppm	cc
Carbonyl Sulphide	171	0.082 0	LD	-	-	12	0.082
Methyl Mercaptan	>1 053	0.442 3	73	661.4	3.846 0	>1 688	4.288 3
Ethyl Mercaptan	>1 073	>0.450 7	180	1 631	9.484 3	>1 593	>9.935 0
i-Propyl Mercaptan	286	0.120 1	55	498.3	2.897 6	484	3.017 7
n-Propyl Mercaptan	69	0.029 0	25	226.5	1.317 1	216	1.346 1
s-Butyl Mercaptan	45	0.018 9	33	299	1.738 7	282	1.757 6
n-Butyl Mercaptan	7	0.002 9	6	54.4	0.316 3	51	0.319 2

Note: LD Less than detection limit (5-10 ppm).
(1) Not corrected.
(2) Corrected.

LODGEPOLE STUDY
CONDENSATE ANALYSIS

SAMPLE NUMBER G5-784 (Boot; liquid only, no vapour fraction*)

FLASHING AND GAS VOLUME DATA

	Mercaptan Analysis	COS Analysis
Volume Flashed Gas	*	*
Weight Flashed Liquid		
Density Liquid, g/cc	0.787 8	0.787 8
Condensate Vaporization Volume, m^3/m^3	138.8	138.8
Correction Factor (Liquid Analysis)	9	9
Liquid Volume		
Liquid's Gas Volume		
Total Sample Gas Volume		

ANALYSIS DATA

Compound	Vapour Fraction		Liquid Fraction			Total Sample	
	ppm	cc	ppm (1)	ppm (2)	cc	ppm	cc
Carbonyl Sulphide	*	*	LD			LD	
Methyl Mercaptan	*	*	52	468		468	
Ethyl Mercaptan	*	*	122	1 098		1 098	
i-Propyl Mercaptan	*	*	40	360		360	
n-Propyl Mercaptan	*	*	19	171		171	
s-Butyl Mercaptan	*	*	31	279		279	
n-Butyl Mercaptan	*	*	6	54		54	

Note: LD Less than detection limit (5-10 ppm).
(1) Not corrected.
(2) Corrected.

RECOMBINATION FOR ANALYSIS ON A TOTAL GAS EFFLUENT BASES
WELL: 13-12-48-12W5 (1987, ANALYSED WITHIN 6 HOURS)
PRODUCTION RATE DATA: OCTOBER 1987 PRODUCTION RATES

High-stage rate gas	159.7×10^3 m^3/d
Gas equivalent of condensate	65.6×10^3 m^3/d
Total production	225.2×10^3 m^3/d

Compound	Gas		Liquid		Total Gas Effluent	
	ppm	m^3/d	ppm	m^3/d	ppm	m^3/d
Carbonyl Sulphide	55	8.784	97	6.354	67	15.138
Methyl Mercaptan	17	2.715	39	2.555	23	5.270
Ethyl Mercaptan	11	1.757	50	3.275	22	5.032
i-Propyl Mercaptan	10	1.597	65	4.258	26	5.855
n-Propyl Mercaptan	LD	-	49	3.210	14	3.210
s-Butyl Mercaptan	LD	-	122	7.991	35	7.991
n-Butyl Mercaptan	LD	-	19	1.245	6	1.245
Carbon Disulphide	LD	-	LD	-	LD	-

Note: LD Less than detection limit (5-10 ppm).

CONCENTRATION OF SULPHUR COMPOUNDS ON A SAMPLE BASIS
WELL: 13-12-48-12W5 (1987, ANALYSED WITHIN 6 HOURS)

Compound	Wellhead Separator	
	Gas (ppm)	Condensate (ppm)
Carbonyl Sulphide	55	97
Methyl Mercaptan	17	39
Ethyl Mercaptan	11	50
i-Propyl Mercaptan	10	65
n-Propyl Mercaptan	LD	49
s-Butyl Mercaptan	LD	122
n-Butyl Mercaptan	LD	19
Carbon Disulphide	LD	LD

Note: LD Less than detection limit (5-10 ppm).

LODGEPOLE STUDY
GAS ANALYSIS

SAMPLE NUMBER G1-1087 (ANALYSED WITHIN 6 HOURS)

Compound	Concentration (ppm)
Carbonyl Sulphide	55
Methyl Mercaptan	17
Ethyl Mercaptan	11
i-Propyl Mercaptan	10
n-Propyl Mercaptan	LD
s-Butyl Mercaptan	LD
n-Butyl Mercaptan	LD

Note: LD Less than detection limit (5-10 ppm).

LODGEPOLE STUDY
CONDENSATE ANALYSIS

SAMPLE NUMBER P5-1087 (ANALYSED WITHIN 6 HOURS)

FLASHING AND GAS VOLUME DATA

	Mercaptan Analysis	COS Analysis
Volume Flashed Gas, cc	550	550
Weight Flashed Liquid, g	1.766 7	1.766 7
Density Liquid, g/cc	0.814 5	0.814 5
Condensate Vaporization Volume, m^3/m^3	143.5	143.5
Correction Factor (Liquid Analysis)	8.7	8.7
Liquid Volume, cc	2.169 1	2.169 1
Liquid's Gas Volume, cc	311	311
Total Sample Gas Volume, cc	861	861

ANALYSIS DATA

Compound	Vapour Fraction		Liquid Fraction			Total Sample	
	ppm	cc	ppm (1)	ppm (2)	cc	ppm	cc
Carbonyl Sulphide	152	0.083 6	LD	-	-	97	0.083 6
Methyl Mercaptan	61	0.033 6	LD	-	-	39	0.033 6
Ethyl Mercaptan	49	0.027 0	6	52.2	0.016 2	50	0.043 2
i-Propyl Mercaptan	47	0.025 9	11	95.7	0.029 8	65	0.055 7
n-Propyl Mercaptan	22	0.012 1	11	95.7	0.029 8	49	0.041 9
s-Butyl Mercaptan	34	0.018 7	32	278.4	0.086 6	122	0.105 3
n-Butyl Mercaptan	LD	-	6	52.2	0.016 2	19	0.016 2

Note: LD Less than detection limit (5-10 ppm).

RECOMBINATION FOR ANALYSIS ON A TOTAL GAS EFFLUENT BASIS
WELL: 13-12-48-12W5 (1987, ANALYSED AFTER 7 MONTHS)
PRODUCTION RATE DATA: OCTOBER 1987 PRODUCTION RATES

High-stage rate gas	159.7×10^3 m^3/d
Gas equivalent of condensate	65.5×10^3 m^3/d
Total production	225.2×10^3 m^3/d

Compound	Gas		Liquid		Total Gas Effluent	
	ppm	m^3/d	ppm	m^3/d	ppm	m^3/d
Carbonyl Sulphide	NA	-	-	-	-	-
Methyl Mercaptan	22	3.513 4	57	3.733 5	32	7.246 9
Ethyl Mercaptan	19	3.034 3	67	4.388 5	33	7.422 8
i-Propyl Mercaptan	20	3.194 0	84	5.502	39	8.696
n-Propyl Mercaptan	LD	-	45	2.947 5	13	2.947 5
s-Butyl Mercaptan	15	2.395 5	117	7.663 5	45	10.059
n-Butyl Mercaptan	LD	-	18	1.179 0	5	1.179 0
Carbon Disulphide	LD	-	LD	-	LD	-

Note: LD Less than detection limit (5-10 ppm).
NA Not analysed.

CONCENTRATION OF SULPHUR COMPOUNDS ON A SAMPLE BASIS
WELL: 13-12-48-12W5 (1987, ANALYSED AFTER 7 MONTHS)

Compound	Wellhead Separator	
	Gas (ppm)	Condensate (ppm)
Carbonyl Sulphide	NA	NA
Methyl Mercaptan	22	57
Ethyl Mercaptan	19	67
i-Propyl Mercaptan	20	84
n-Propyl Mercaptan	LD	45
s-Butyl Mercaptan	15	117
n-Butyl Mercaptan	LD	18
Carbon Disulphide	LD	LD

Note: LD Less than detection limit (5-10 ppm).
NA Not analysed.

LODGEPOLE STUDY
GAS ANALYSIS

SAMPLE NUMBER G1-1087 (ANALYSED AFTER 7 MONTHS)

Compound	Concentration (ppm)
Carbonyl Sulphide	NA
Methyl Mercaptan	22
Ethyl Mercaptan	19
i-Propyl Mercaptan	20
n-Propyl Mercaptan	LD
s-Butyl Mercaptan	15
n-Butyl Mercaptan	LD

Note: LD Less than detection limit (5-10 ppm).
NA Not analysed.

LODGEPOLE STUDY
CONDENSATE ANALYSIS

SAMPLE NUMBER P5-1087 (ANALYSED ATER 7 MONTHS)

FLASHING AND GAS VOLUME DATA

	Mercaptan Analysis	COS Analysis
Volume Flashed Gas, cc	690	NA
Weight Flashed Liquid, g	1.309 7	NA
Density Liquid, g/cc	0.814 5	NA
Condensate Vaporization Volume, m^3/m^3	144	NA
Correction Factor (Liquid Analysis)	8.7	NA
Liquid Volume, cc	1.608 0	NA
Liquid's Gas Volume, cc	232	NA
Total Sample Gas Volume, cc	922	NA

ANALYSIS DATA

Compound	Vapour Fraction		Liquid Fraction			Total Sample	
	ppm	cc	ppm (1)	ppm (2)	cc	ppm	cc
Carbonyl Sulphide	NA	-	NA	-	-	-	-
Methyl Mercaptan	76	0.052 4	LD	-	0.016 1	57	0.052 4
Ethyl Mercaptan	66	0.045 5	8	69.6	0.030 3	67	0.061 6
i-Propyl Mercaptan	68	0.046 9	15	130.5	0.022 2	84	0.077 2
n-Propyl Mercaptan	28	0.019 3	11	95.77	0.076 7	45	0.041 5
s-Butyl Mercaptan	45	0.031 1	38		0.014 1	117	0.107 8
n-Butyl Mercaptan	4	0.002 8	7	330.6		18	0.016 9
				60.9			

Note: LD Less than detection limit (5-10 ppm).
NA Not analysed.
(1) Not corrected.
(2) Corrected.

APPENDIX 4 CHROMATOGRAMS

SINGLE CHANNEL METHOD: RECALC

SECTION 1: GENERAL
PAGE 1
ANALYSIS PARAMETERS
CHANNEL: 1A
DETECTOR: 1
CALCULATION: ES
HT/AREA: S
STOP TIME: 32.50
NUMB EXPECTED PKS: 40
EQUILIBRATION TIME: 0
UNRETAINED PK TIME: 0.00
SLICE WIDTH: 10

PAGE 2
SAMPLE PARAMETERS
RUN TYPE: A
SAMPLE ID: LODGEPOLE
DIVISOR: 1.000000
AMT STD: 1.000000
MLTPLR: 1.000000

PAGE 3
REPORT INSTRUCTIONS
WHERE TO REPORT: P1
COPIES: 1
TITLE: LODGEPOLE
FORMAT: E
DECIMAL PLACE: 4
RESULT UNITS:
REPORT UNIDENT PKS: N
REPORT INSTRUMENT CONDITIONS: N

PAGE 4
PLOT INSTRUCTIONS
PLOT: Y
REPLOT WITH BASELINES: N
RAW DATA LOCATION: F
ZERO OFFSET: 10
ANNOTATION
RETENTION TIME: Y
PLOT CONTROL: Y
TIME TICKS: Y
TIME EVENTS: N
PK START/END: Y

PAGE 5
CHART SPEED
PAGES OR CM/MIN: C
INIT VALUE: 0.5

PAGE 6
PLOT ATTEN
INIT PLOT ATTEN: 512

Mercaptan & CS_2 Analyses
Porapak - Porapak Columns
1984 Gas Samples
High Pressure Separator

SINGLE CHANNEL METHOD: RECALC

SECTION 2: TIME EVENTS
PAGE 1

LINE#	TIME	EVENT	VALUE
1	0.00	PR	30
2	0.00	SN	4
3	0.00	T%	100.0
4	0.00	WI	4.0
5	0.00	II	4.50

SECTION 3: PEAK TABLE
PAGE 1

STD PK#: 0
RELATIVE RETEN PK#: 0
RESOLUTION PK#: 0
RESOLUTION MINIMUM: 0.0
TOL%: 5.0
IDENTIFICATION TIME WINDOWS +/-
REF
%: 10
MIN: 0.10
NON REF
%: 5
MIN: 0.10
CALIBRATION CURVE: LN
NUMBER CALIB LEVELS: 4
NUMBER INJ/LEVEL: 2
UNIDENT PK FACTOR: 0.000E+00

PAGE 2

PK#	TIME	NAME	AMOUNT	R	GR	COEF0	COEF1	COEF2	COEF3
1	10.700	*C1SH	105.30			5.900E+04	9.776E+02	0.000E+00	0.000E+00
2	13.000	*C2SH	94.950			4.419E+04	9.276E+02	0.000E+00	0.000E+00
3	15.400	*IC3SH	83.990			3.422E+04	1.046E+03	0.000E+00	0.000E+00
4	17.000	*NC3SH	53.250			3.599E+04	1.331E+03	0.000E+00	0.000E+00
5	19.600	*SC4SH	118.25			9.350E+04	1.084E+03	0.000E+00	0.000E+00
6	21.010	*NC4SH	21.950			5.375E+03	1.009E+03	0.000E+00	0.000E+00

SINGLE 'CHANNEL METHOD: RECALC

SECTION 4: GC INSTRUMENT CONTROL
PAGE 1
COL TEMP
ISO/INIT COL TEMP: 90
INIT HOLD TIME: 8.00

STEP#	FINAL TEMP	RATE	HOLD TIME
1	170	5.0	4.00
2	200	20.0	3.00

PAGE 2
DETECTORS
DET A TYPE: FPD
DET B TYPE: FID

LINE#	TIME	SIDE	ATTN	RANGE	ZERO
1	0.00	A	16	10	Y
2	0.00	B	128	12	Y

PAGE 3
TEMP/FLOW
INJ A TEMP: 210
INJ B TEMP: 60
ION TEMP: 220
TCD TEMP:
TCD FIL TEMP:
AUX TEMP:
COL A FLOW: 30
COL B FLOW: 30

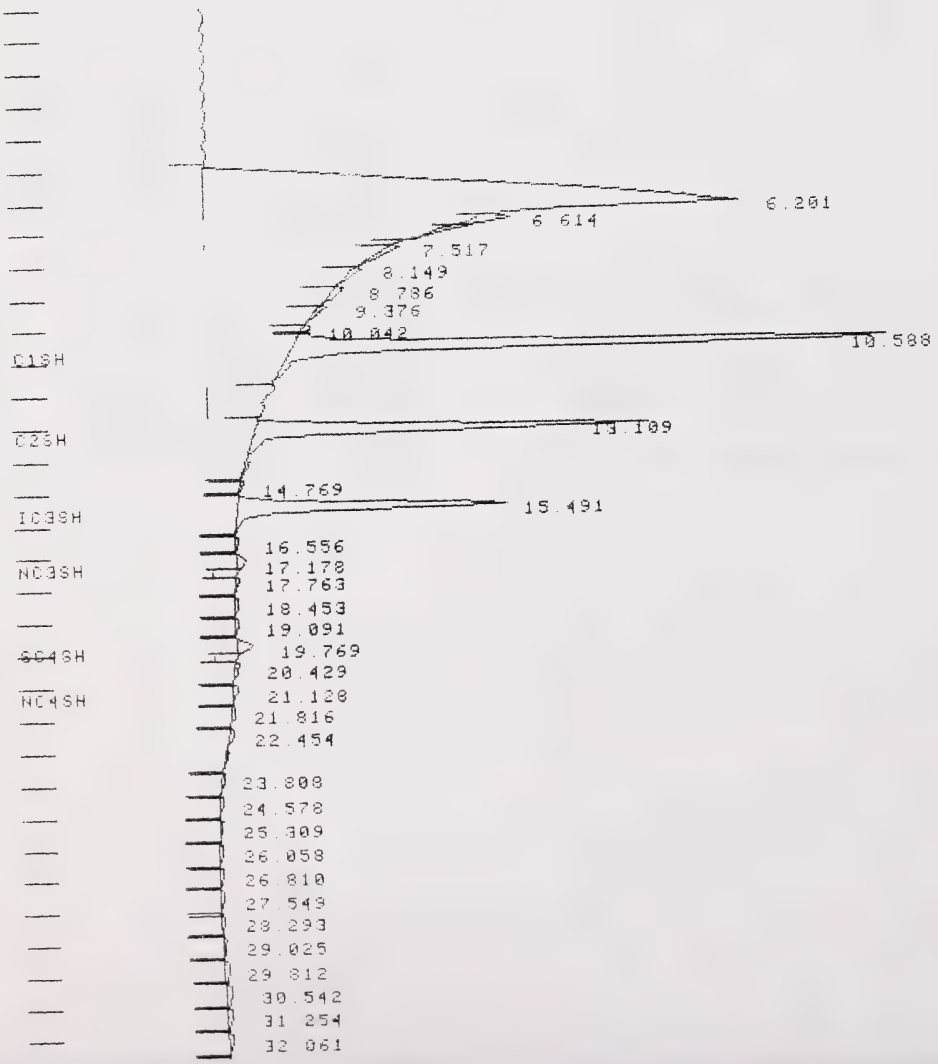
PAGE 4

LINE#	TIME	RELAY ON	RELAY OFF
1	0.00		12
2	0.01	1	
3	4.00	2	
4	22.00		2

SECTION 7: POST RUN
PAGE 1

Sample: G1-684
High Separator Gas
10-2 Well

CHART SPEED: 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 1 MIN/TICK



RECALCULATE ON FILE: LODG077

CHANNEL: 1A - 1 TITLE: LODGEPOLE 11:41 13 MAY 88

SAMPLE: G1-684 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	80.4501	10.598	0.088	558	UD	?	
2	C2SH	44.2130	13.109	0.109	429	UD	?	
3	IC3SH	39.5090	15.491	0.091	345	UD	?	
4	NC3SH	11.9843	17.178	0.178	63	UD	?	
5	SC4SH	18.6724	19.769	0.169	86	UD	?	
6	NC4SH	5.2798	21.128	0.118	47	UD	?	
TOTALS:		180.1086		0.753	1528			

TOTAL UNIDENT AREA/HT: 2026

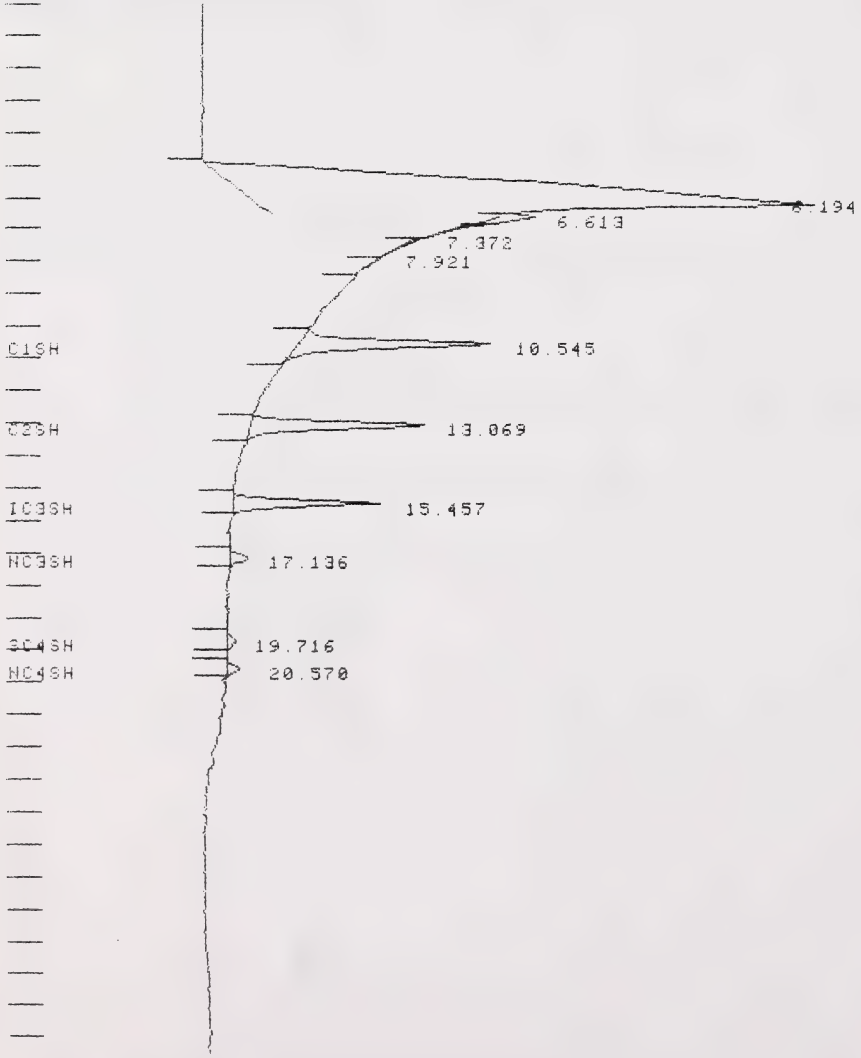
DETECTED PKS: 34 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 236.8 OFFSET: -373

Sample: G1-784
High Pressure Separator Gas
13-12 Well

CHART SPEED: 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 1 MIN/TICK



RECALCULATE ON FILE: LODG084

CHANNEL: 1A - 1 TITLE: LODGEPOLE 9:10 16 MAY 88

SAMPLE: 61-784 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	38.8496	10.545	0.445	335	BB		13.25
2	C2SH	34.1022	13.069	0.069	320	BB		13.56
3	IC3SH	33.7560	15.457	0.057	290	VD	?	
4	NC3SH	18.9090	17.136	0.136	100	VD	?	
5	SC4SH	17.0464	19.716	0.116	71	VD	?	
6	NC4SH	8.0131	20.570	-0.440	84	VD	?	
TOTALS:		149.4763		0.383	1200			

TOTAL UNIDENT AREA/HT: 827

DETECTED PKS: 11 REJECTED PKS: 2

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 370.3 OFFSET: -228

```
    SINGLE   CHANNEL METHOD: CALC


    SECTION 1: GENERAL
    PAGE 1
ANALYSIS PARAMETERS
CHANNEL: 1A
DETECTOR: 1
CALCULATION: ES
HT/AREA: S
STOP TIME:  40.00
NUMB EXPECTED PKS:   40
EQUILIBRATION TIME:  0
UNRETAINED PK TIME:   0.00
SLICE WIDTH:  10

    PAGE 2
SAMPLE PARAMETERS
RUN TYPE: A
SAMPLE ID: LODGEP0LE
DIVISOR: 1.000000
AMT STD: 1.000000
MLTPLR: 1.000000

    PAGE 3
REPORT INSTRUCTIONS
WHERE TO REPORT: P1
COPIES:   1
TITLE: LODGEPOLE
FORMAT: E
DECIMAL PLACE: 4
RESULT UNITS:
REPORT UNIDENT PKS: N
REPORT INSTRUMENT CONDITIONS: N

    PAGE 4
PLOT INSTRUCTIONS
PLOT: Y
REPLOT WITH BASELINES: N
  RAW DATA LOCATION: F
ZERO OFFSET: 10
ANNOTATION
  RETENTION TIME: Y
  PLOT CONTROL: Y
  TIME TICKS: N
  TIME EVENTS: N
  PK START/END: N

    PAGE 5
CHART SPEED
  PAGES OR CM/MIN: C
  INIT VALUE:  0.5

    PAGE 6
PLOT ATTEN
INIT PLOT ATTEN: 512
```

Mercaptan & CS_2 Analyses
Porapak - Porapak Columns
1984 Condensate Samples
Flashed Gas Fractions

SINGLE CHANNEL METHOD: CALC

SECTION 2: TIME EVENTS
PAGE 1

LINE#	TIME	EVENT	VALUE
1	0.00	PR	50
2	0.00	SN	4
3	0.00	T%	100.0
4	0.00	WI	4.0
5	0.00	II	4.50
6	16.20	T%	100.0

SECTION 3: PEAK TABLE
PAGE 1

STD PK#: 0
RELATIVE RETEN PK#: 0
RESOLUTION PK#: 0
RESOLUTION MINIMUM: 0.0
TOL%: 5.0
IDENTIFICATION TIME WINDOWS +/-
REF
%: 10
MIN: 0.10
NON REF
%: 5
MIN: 0.10
CALIBRATION CURVE: LN
NUMBER CALIB LEVELS: 4
NUMBER INJ/LEVEL: 2
UNIDENT PK FACTOR: 0.000E+00

PAGE 2

PK#	TIME	NAME	AMOUNT	R	GR	COEF0	COEF1	COEF2	COEF3
1	10.500	*C1SH	1053.0			-8.328E+04	1.056E+04	0.000E+00	0.000E+00
2	13.000	*C2SH	1073.7			5.604E+04	1.056E+04	0.000E+00	0.000E+00
3	15.460	*IC3SH	312.85			1.061E+05	1.157E+04	0.000E+00	0.000E+00
4	16.940	*NC3SH	53.250			3.598E+04	1.331E+03	0.000E+00	0.000E+00
5	19.600	*SC4SH	118.25			9.350E+04	1.083E+03	0.000E+00	0.000E+00
6	21.010	*NC4SH	21.950			5.375E+03	1.009E+03	0.000E+00	0.000E+00

SINGLE CHANNEL METHOD: CALC

SECTION 4: GC INSTRUMENT CONTROL
PAGE 1
COL TEMP
ISO/INIT COL TEMP: 90
INIT HOLD TIME: 8.00

STEP#	FINAL TEMP	RATE	HOLD TIME
1	170	5.0	4.00
2	200	20.0	3.00

PAGE 2
DETECTORS
DET A TYPE: FPD
DET B TYPE: FID

LINE#	TIME	SIDE	ATTN	RANGE	ZERO
1	0.00	A	16	10	Y
2	0.00	B	128	12	Y
3	3.00	A	16	8	Y
4	16.00	A	16	10	Y

PAGE 3
TEMP/FLOW
INJ A TEMP: 210
INJ B TEMP: 60
ION TEMP: 220
TCD TEMP:
TCD FIL TEMP:
AUX TEMP:
COL A FLOW: 30
COL B FLOW: 30

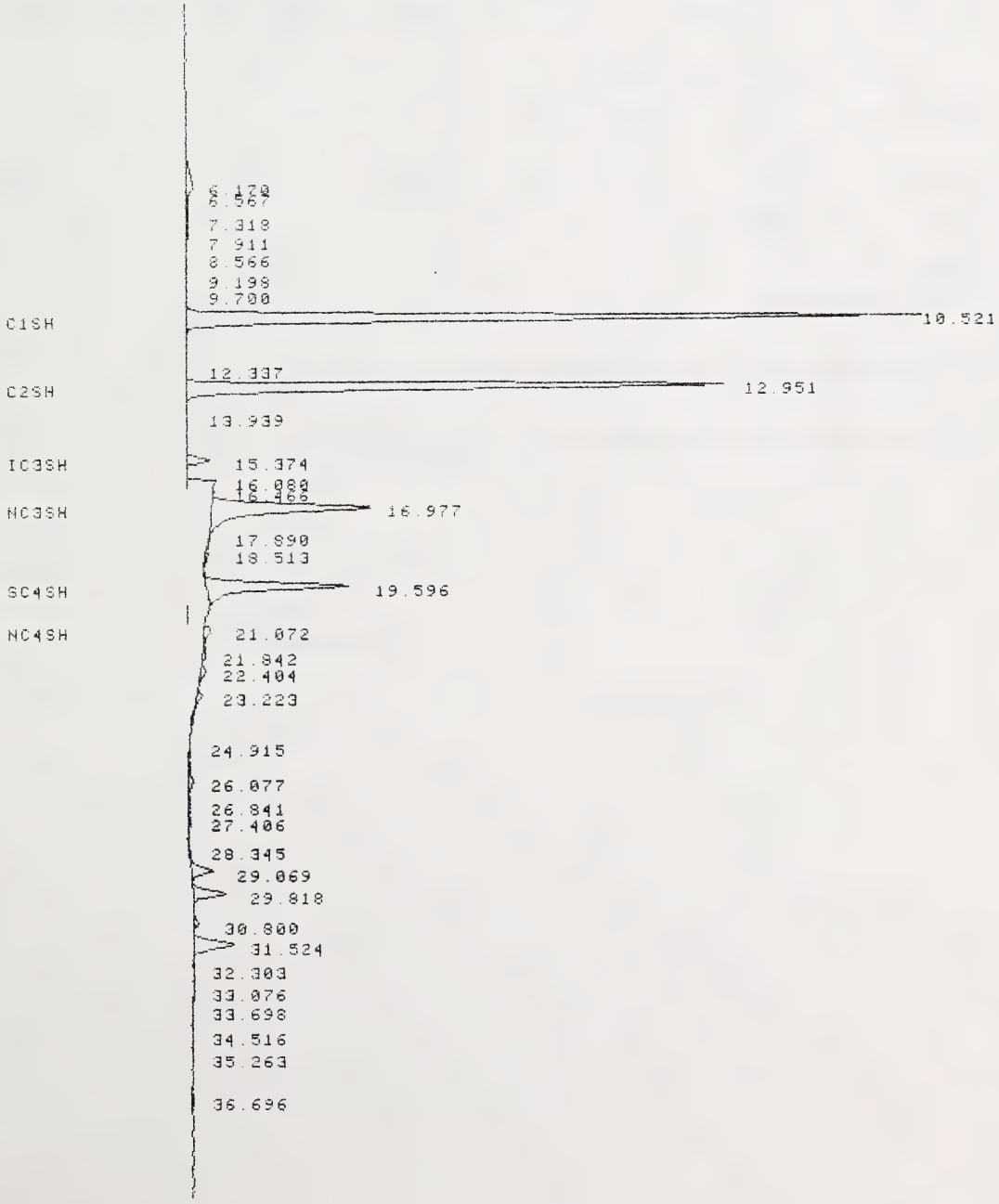
PAGE 4

LINE#	TIME	RELAY ON	RELAY OFF
1	0.00		12
2	0.01	1	
3	4.00	2	
4	22.00		2

SECTION 7: POST RUN
PAGE 1

Sample: P1-684
High Pressure Separator
10-2 Well
Flashed Gas

CHART SPEED: 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 2 MIN/TICK



RECALCULATE ON FILE: LOD6071

CHANNEL: 1A - 1 TITLE: LODGEPOLE 10:49 21 DEC 87

SAMPLE: P1-684 METHOD: CALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	738.2640	10.521	0.021	707	UD	?	
2	C2SH	618.0840	12.951	-0.049	580	UD	?	
3	IC3SH	147.1360	15.374	-0.086	118	UD	?	
4	NC3SH	45.8238	16.977	0.037	318	UD	?	
5	SC4SH	40.9736	19.596	-0.004	292	UD	?	
6	NC4SH	6.4906	21.072	0.062	59	UD	?	
TOTALS:		1596.872		-0.019	2074			

TOTAL UNIDENT AREA/HT: 2147484416

DETECTED PKS: 40 REJECTED PKS: 25

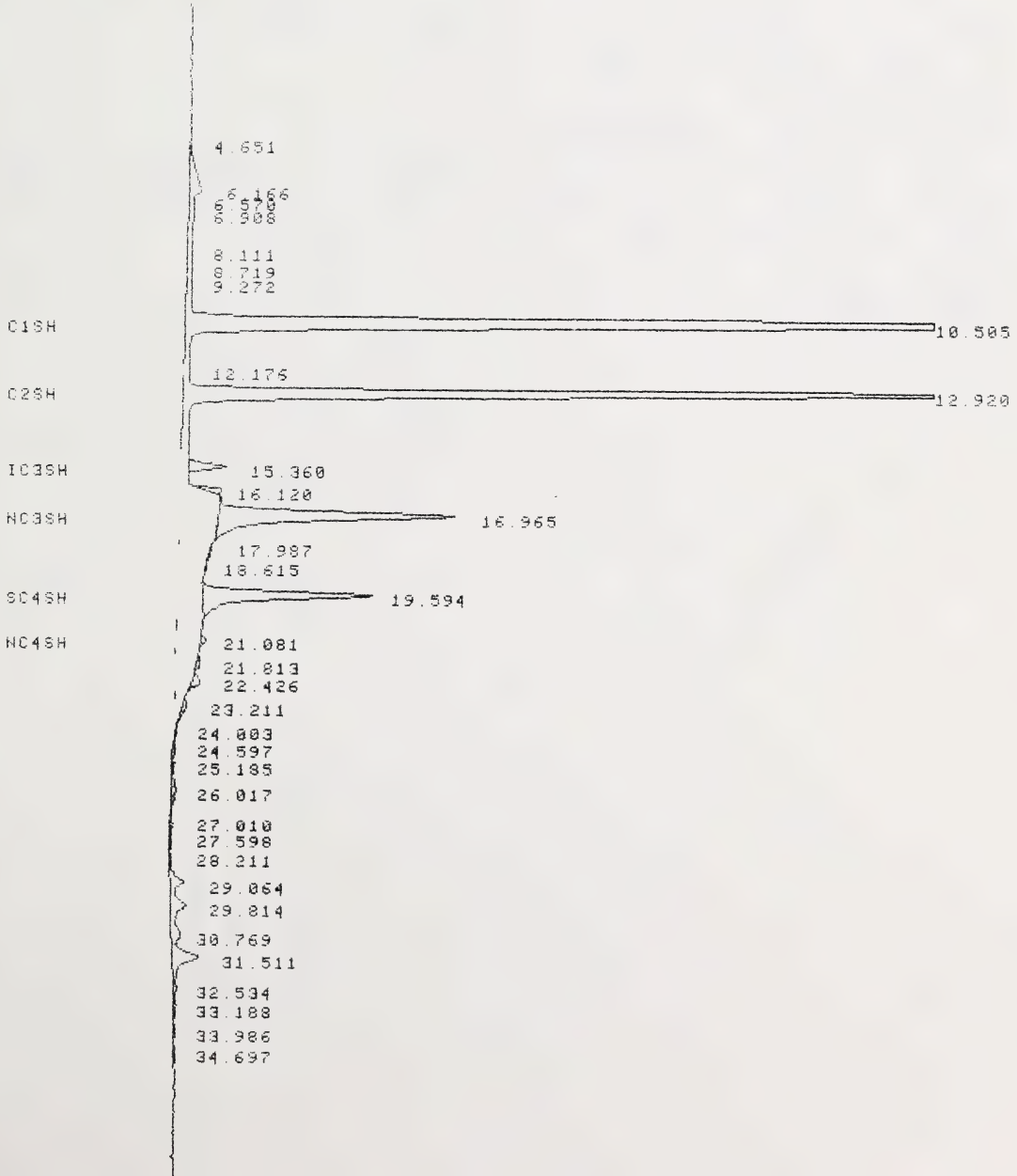
DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 1.1 OFFSET: 295

ERRORS:
PEAK STORAGE FULL

Sample: P2-684
Low Pressure Separator
10-2 Well
Flashed Gas

CHART SPEED: 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 2 MIN/TICK



RECALCULATE ON FILE: LODG073

CHANNEL: 1A - 1 TITLE: LODGEPOLE 9:30 22 DEC 87

SAMPLE: P2-584 METHOD: CALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	1109.976	10.505	0.005	1059	UD	?	
2	C2SH	797.6040	12.920	-0.080	750	UD	?	
3	IC3SH	184.1600	15.360	-0.100	150	UD	?	
4	NC3SH	54.4422	16.965	0.025	382	UD	?	
5	SC4SH	44.1143	19.594	-0.006	321	UD	?	
6	NC4SH	6.1879	21.081	0.071	56	UD	?	
TOTALS:		2196.484		-0.085	2718			

TOTAL UNIDENT AREA/HT: 966

DETECTED PKS: 40 REJECTED PKS: 21

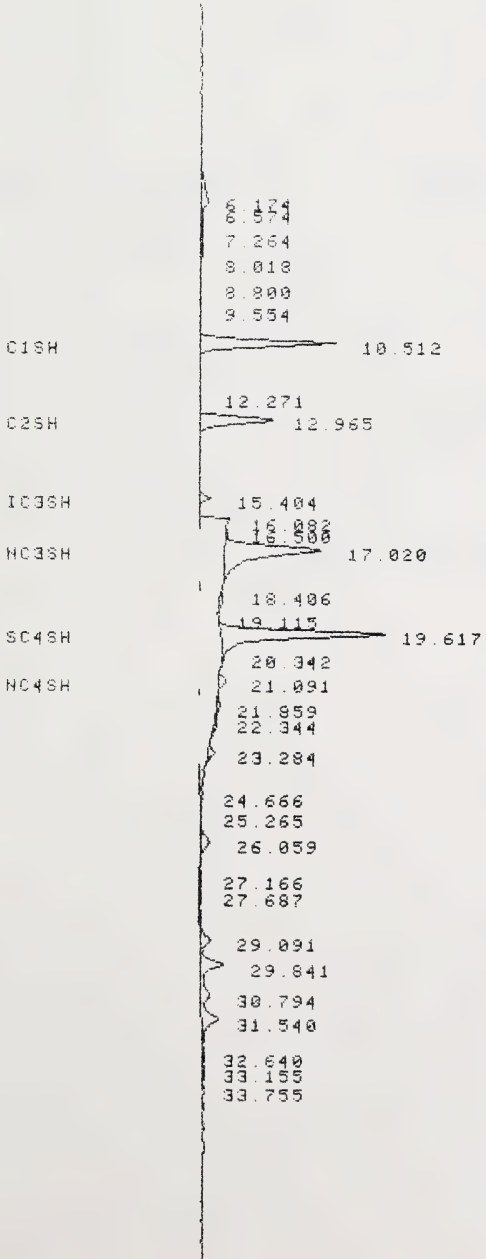
DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 1.1 OFFSET: 20

ERRORS:
  PEAK STORAGE FULL

Sample: G4-784
High Pressure Separator
13-12 Well
Flashed Gas

CHART SPEED: 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 2 MIN/TICK



RECALCULATE ON FILE: LODG076

CHANNEL: 1A - 1 TITLE: LODGEPOLE 9:25 23 DEC 87

SAMPLE: G4-784 METHOD: CALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	289.4640	10.512	0.012	282	BB		11.44
2	C2SH	224.1960	12.965	-0.035	207	VB		13.44
3	IC3SH	96.2280	15.404	-0.056	74	VD	?	
4	NC3SH	35.0096	17.020	0.080	236	VD	?	
5	SC4SH	42.8147	19.617	0.017	309	VD	?	
6	NC4SH	6.3897	21.091	0.081	58	VD	?	
TOTALS:		694.1020		0.099	1166			

TOTAL UNIDENT AREA/HT: 684

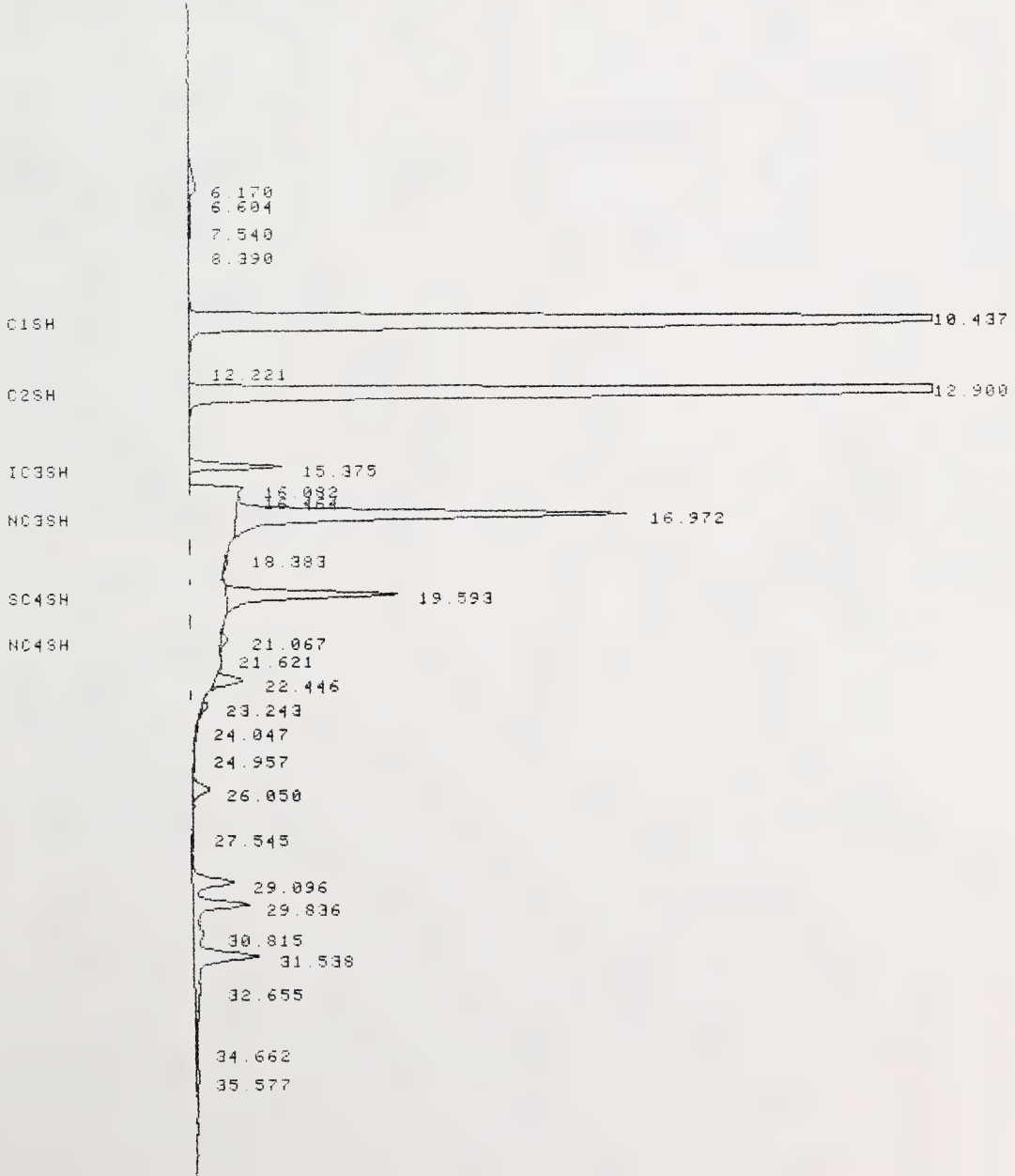
DETECTED PKS: 34 REJECTED PKS: 20

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 1.1 OFFSET: -47

Sample: G6-784
Low Pressure Separator
13-12 Well
Flashed Gas

CHART SPEED: 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 2 MIN/TICK



RECALCULATE ON FILE: LODG077

CHANNEL: 1A - 1 TITLE: LODGEPOLE 14:28 23 DEC 87

SAMPLE: 66-784 METHOD: CALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	1107.864	10.437	-0.063	1057	BV		20.50
2	C2SH	1122.852	12.900	-0.100	1058	VB	?	18.13
3	IC3SH	285.9760	15.375	-0.085	238	BV		11.63
4	NC3SH	68.6839	16.872	0.032	489	UD	?	
5	SC4SH	44.7641	18.593	-0.007	327	UD	?	
6	NC4SH	7.1969	21.067	0.057	66	UD	?	
TOTALS:		2637.337		-0.166	3235			

TOTAL UNIDENT AREA/HT: 4294967296

DETECTED PKS: 33 REJECTED PKS: 15

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 1.1 OFFSET: -163

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    SINGLE   CHANNEL METHOD: RECALC


    SECTION 1: GENERAL
    PAGE 1
ANALYSIS PARAMETERS
CHANNEL: 1A
DETECTOR: 1
CALCULATION: ES
HT/AREA: S
STOP TIME:  52.50
NUMB EXPECTED PKS:   40
EQUILIBRATION TIME:  0
UNRETAINED PK TIME:   0.00
SLICE WIDTH:  10

    PAGE 2
SAMPLE PARAMETERS
RUN TYPE: A
SAMPLE ID: LODGEPOLE
DIVISOR: 1.000000
AMT STD: 1.000000
MLTPLR: 1.000000

    PAGE 3
REPORT INSTRUCTIONS
WHERE TO REPORT: P1
COPIES:   1
TITLE: LODGEPOLE
FORMAT: E
DECIMAL PLACE: 4
RESULT UNITS:
REPORT UNIDENT PKS: N
REPORT INSTRUMENT CONDITIONS: N

    PAGE 4
PLOT INSTRUCTIONS
PLOT: Y
REPLOT WITH BASELINES: N
  RAW DATA LOCATION: F
ZERO OFFSET: 10
ANNOTATION
  RETENTION TIME: Y
  PLOT CONTROL: Y
  TIME TICKS: Y
  TIME EVENTS: N
  PK START/END: Y

    PAGE 5
CHART SPEED
  PAGES OR CM/MIN: C
  INIT VALUE:  0.5

    PAGE 6
PLOT ATTEN
INIT PLOT ATTEN: 512
```

Mercaptan & CS_2 Analyses
Porapak - Porapak Columns
1984 Condensate Samples
Flashed Liquid Fractions

SINGLE CHANNEL METHOD: RECALC

SECTION 2: TIME EVENTS
PAGE 1

LINE#	TIME	EVENT	VALUE
1	0.00	PR	30
2	0.00	SN	4
3	0.00	T%	100.0
4	0.00	WI	4.0
5	0.00	II	4.50

SECTION 3: PEAK TABLE
PAGE 1

STD PK#: 0
RELATIVE RETEN PK#: 0
RESOLUTION PK#: 0
RESOLUTION MINIMUM: 0.0
TOL%: 5.0
IDENTIFICATION TIME WINDOWS +/-
REF
%: 10
MIN: 0.10
NON REF
%: 5
MIN: 0.10
CALIBRATION CURVE: LN
NUMBER CALIB LEVELS: 4
NUMBER INJ/LEVEL: 2
UNIDENT PK FACTOR: 0.000E+00

PAGE 2

PK#	TIME	NAME	AMOUNT	R	GR	COEF0	COEF1	COEF2	COEF3
1	10.500	*C1SH	105.30			5.900E+04	9.776E+02	0.000E+00	0.000E+00
2	13.000	*C2SH	94.950			4.419E+04	9.276E+02	0.000E+00	0.000E+00
3	15.400	*IC3SH	83.990			3.422E+04	1.046E+03	0.000E+00	0.000E+00
4	17.000	*NC3SH	53.250			3.599E+04	1.331E+03	0.000E+00	0.000E+00
5	19.600	*SC4SH	118.25			9.350E+04	1.084E+03	0.000E+00	0.000E+00
6	21.010	*NC4SH	21.950			5.375E+03	1.009E+03	0.000E+00	0.000E+00

SINGLE CHANNEL METHOD: RECALC

SECTION 4: GC INSTRUMENT CONTROL
PAGE 1

COL TEMP
ISO/INIT COL TEMP: 90
INIT HOLD TIME: 8.00

STEP#	FINAL TEMP	RATE	HOLD TIME
1	170	5.0	4.00
2	200	20.0	3.00

PAGE 2

DETECTORS
DET A TYPE: FPD
DET B TYPE: FID

LINE#	TIME	SIDE	ATTN	RANGE	ZERO
1	0.00	A	16	10	Y
2	0.00	B	128	12	Y

PAGE 3

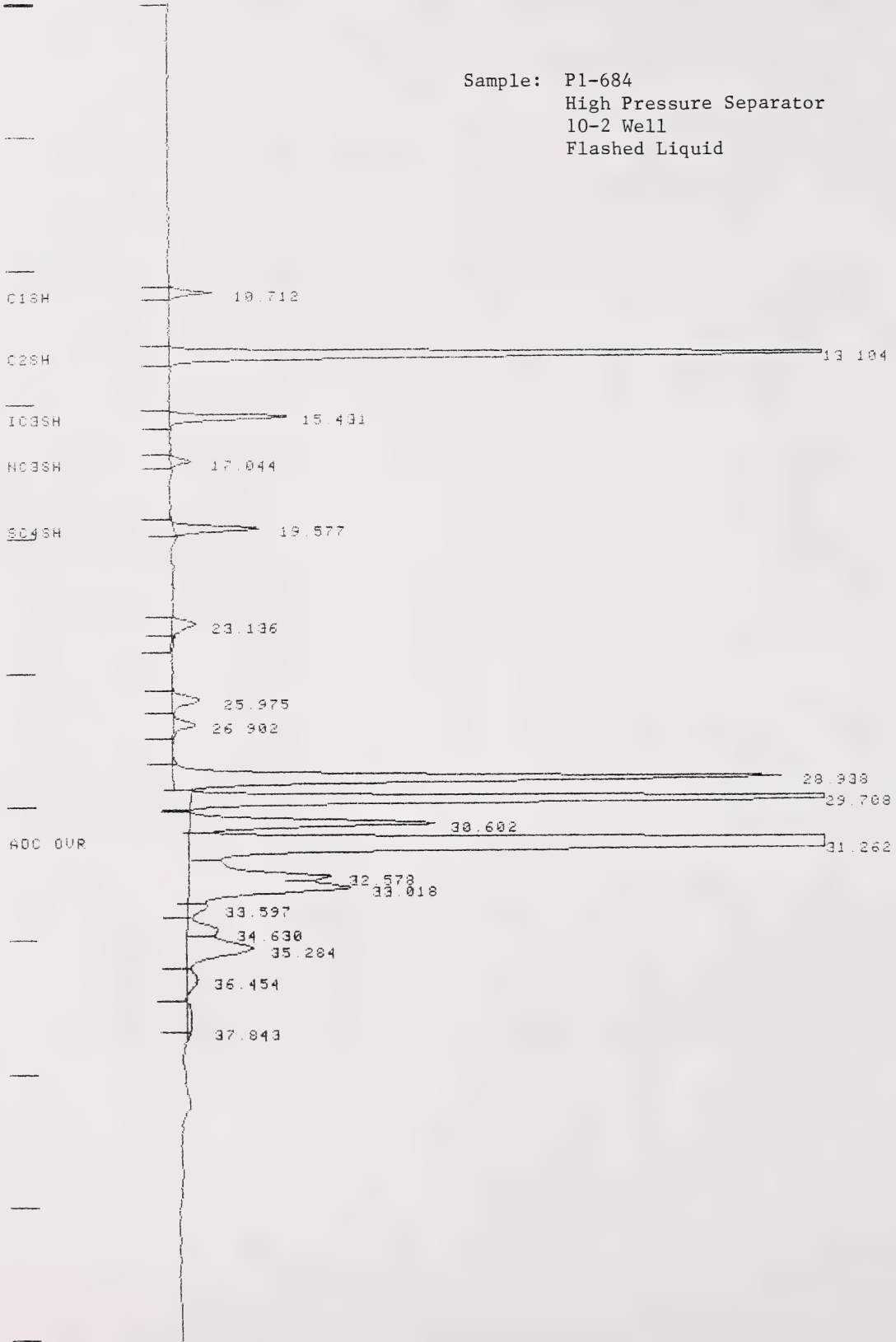
TEMP/FLOW
INJ A TEMP: 210
INJ B TEMP: 60
ION TEMP: 220
TCD TEMP:
TCD FIL TEMP:
AUX TEMP:
COL A FLOW: 30
COL B FLOW: 30

PAGE 4

LINE#	TIME	RELAY ON	RELAY OFF
1	0.00		12
2	0.01	1	
3	4.00	2	
4	22.00		2

SECTION 7: POST RUN
PAGE 1

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK



RECALCULATE ON FILE: GAS075

CHANNEL: 1A - 1 TITLE: LODGEPOLE 15:14 21 DEC 87

SAMPLE: P1-684 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	22.9102	10.712	0.012	174	BB	?	11.31
2	C2SH	77.0501	13.104	0.104	793	BB		11.81
3	IC3SH	34.0698	15.431	0.031	293	BB		12.00
4	NC3SH	19.3048	17.044	0.044	118	BB		15.13
5	SC4SH	36.0164	19.577	-0.023	246	BB		12.44
TOTALS:		189.3513		0.168	1614			

TOTAL UNIDENT AREA/HT: 4010

DETECTED PKS: 19 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 330.3 OFFSET: 909

ERRORS:
ADC OVERANGE

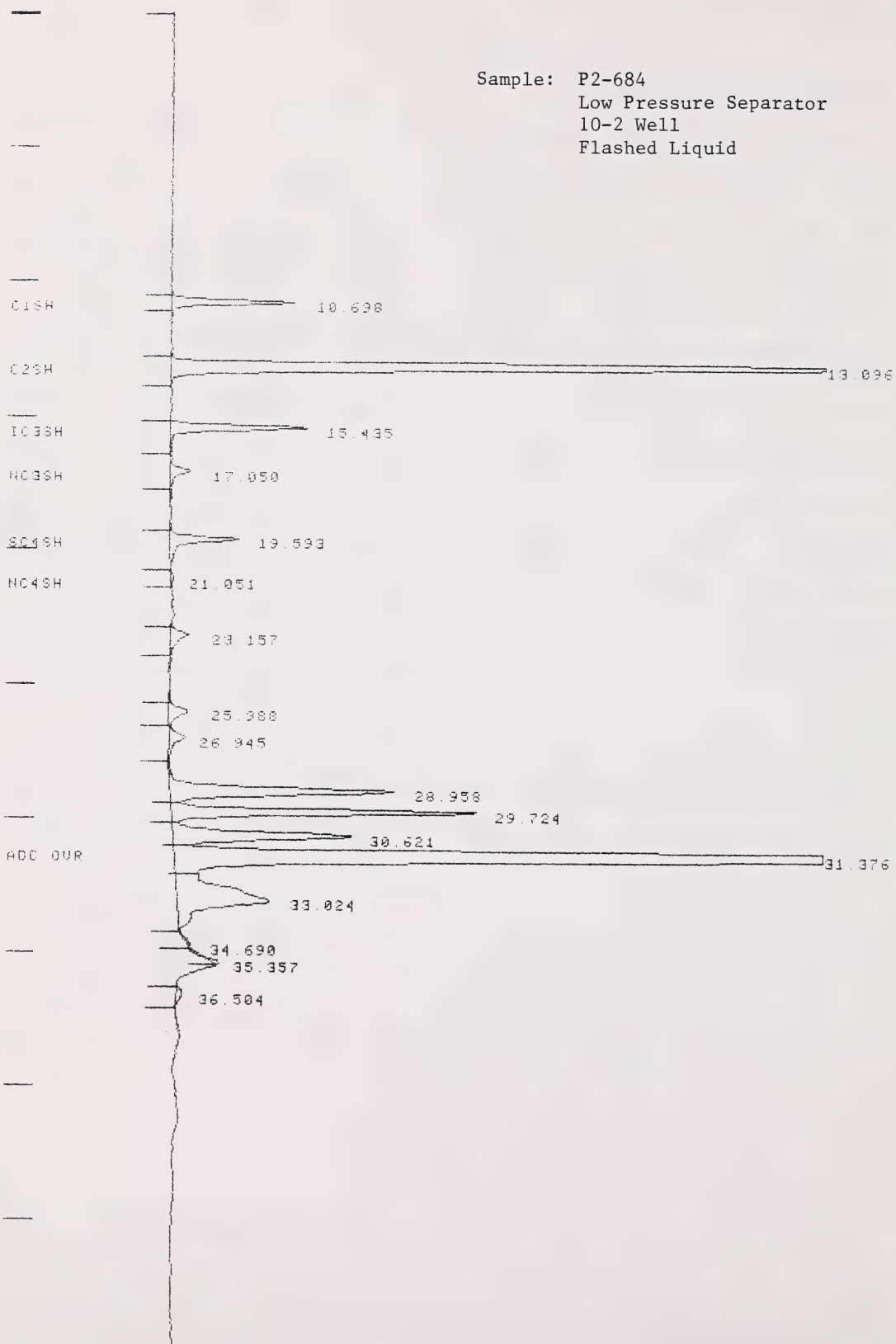


CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK
Sample: P2-684
Low Pressure Separator
10-2 Well
Flashed Liquid
C1SH
10.698
C2SH
13.096
IC3SH
15.435
NC3SH
17.050
SC4SH
19.593
NC4SH
21.051
23.157
25.388
26.945
28.958
29.724
30.621
ADC OVR
31.376
33.024
34.690
35.357
36.504

RECALCULATE ON FILE: GAS082

CHANNEL: 1A - 1 TITLE: LODGEPOLE 12:57 22 DEC 87

SAMPLE: P2-684 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	34.5437	10.698	-0.002	293	BB		11.13
2	C2SH	88.5451	13.096	0.096	908	BB	?	12.50
3	IC3SH	35.7434	15.435	0.035	309	BV		12.13
4	NC3SH	19.0386	17.050	0.050	116	T		15.88
5	SC4SH	32.9812	19.593	-0.007	218	BV		13.06
6	NC4SH	5.4816	21.051	0.041	48	T		30.56
TOTALS:		216.4336		0.213	1893			

TOTAL UNIDENT AREA/HT: 3007

DETECTED PKS: 17 REJECTED PKS: 0

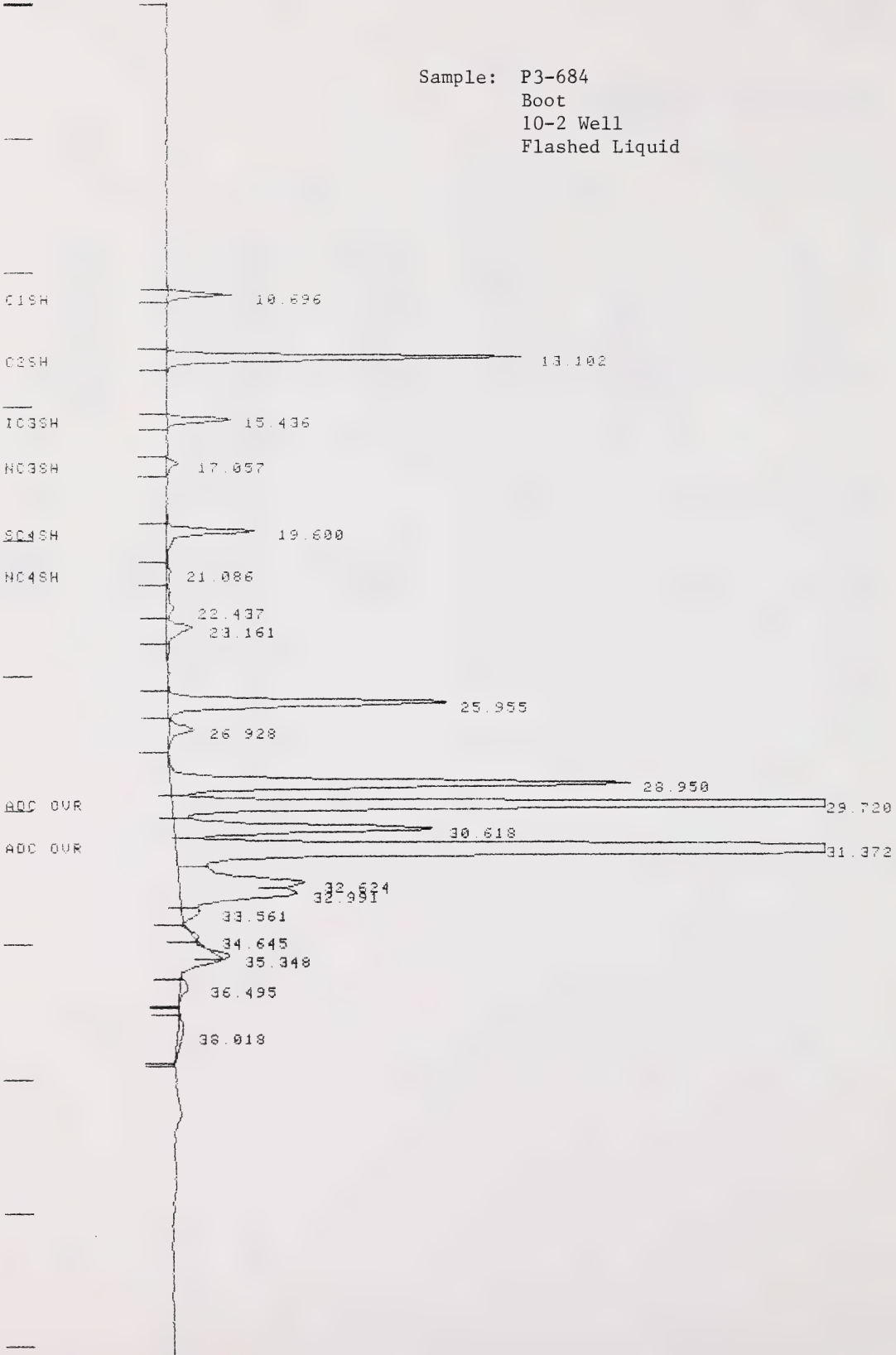
DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 330.3 OFFSET: 163

ERRORS:
ADC OVERANGE

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK

Sample: P3-684
Boot
10-2 Well
Flashed Liquid



RECALCULATE ON FILE: GAS084

CHANNEL: 1A - 1 TITLE: LODGEPOLE 14:55 22 DEC 87

SAMPLE: P3-684 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	26.4296	10.698	-0.004	210	BB	?	11.31
2	C2SH	50.5207	13.102	0.102	497	BB		11.94
3	IC3SH	25.5972	15.436	0.036	212	BB		12.31
4	NC3SH	15.1787	17.057	0.057	87	BB		15.25
5	SC4SH	36.2332	19.600	0.000	248	BV		12.69
6	NC4SH	5.7843	21.086	0.076	52	T	?	23.94
TOTALS:		159.7437		0.267	1306			

TOTAL UNIDENT AREA/HT: 4828

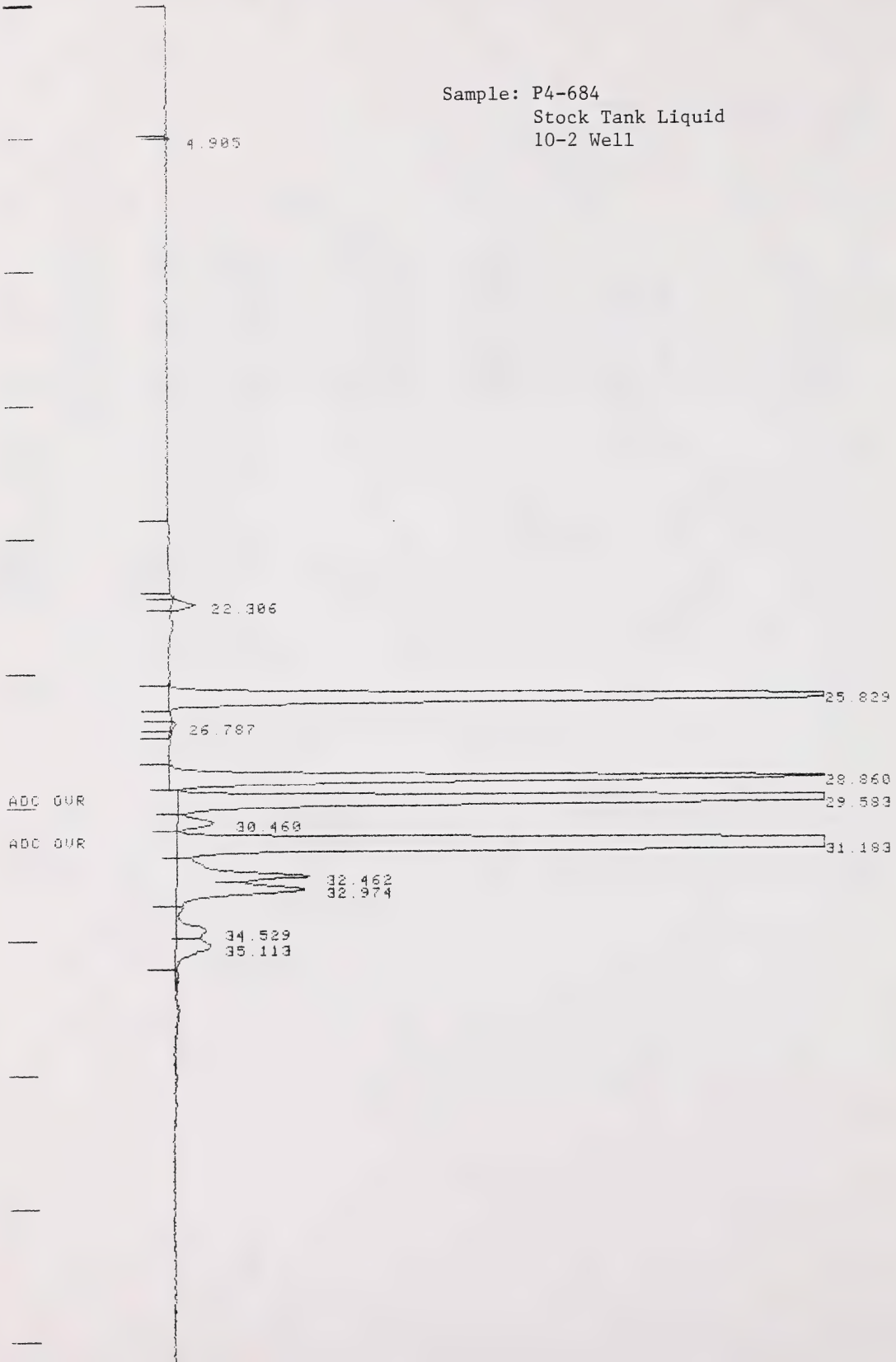
DETECTED PKS: 21 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 330.3 OFFSET: 77

ERRORS:
  ADC OVERANGE

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK



RECALCULATE ON FILE: GAS073

CHANNEL: 1A - 1 TITLE: LODGEPOLE 9:37 30 DEC 87

SAMPLE: P4-624 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
TOTALS:		0.0000			0		

TOTAL UNIDENT AREA/HT: 5056

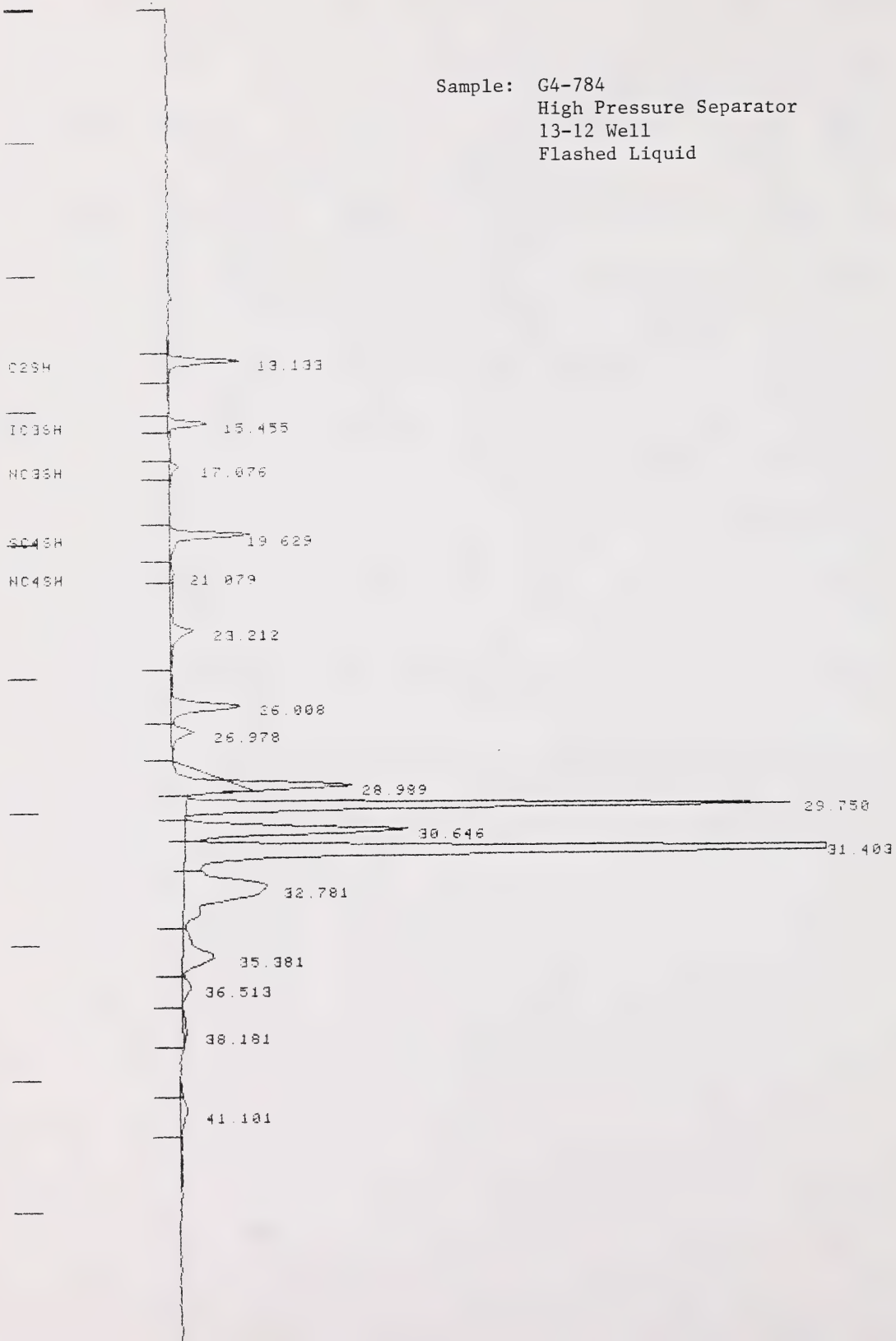
DETECTED PKS: 12 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 330.3 OFFSET: -200

ERRORS:
ADC OVERANGE

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK



RECALCULATE ON FILE: GAS086

CHANNEL: 1A - 1 TITLE: LODGEPOLE 11:32 23 DEC 87

SAMPLE: G4-784 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
1	C2SH	25.1972	13.133	0.133	224	BB	12.50
2	IC3SH	20.5764	15.455	0.055	164	BB	12.81
3	NC3SH	13.5815	17.076	0.076	75	BB	15.50
4	SC4SH	34.9324	19.629	0.029	236	BV	13.13
5	NC4SH	6.2888	21.079	0.069	57	T	20.06
TOTALS:		100.5763		0.362	756		

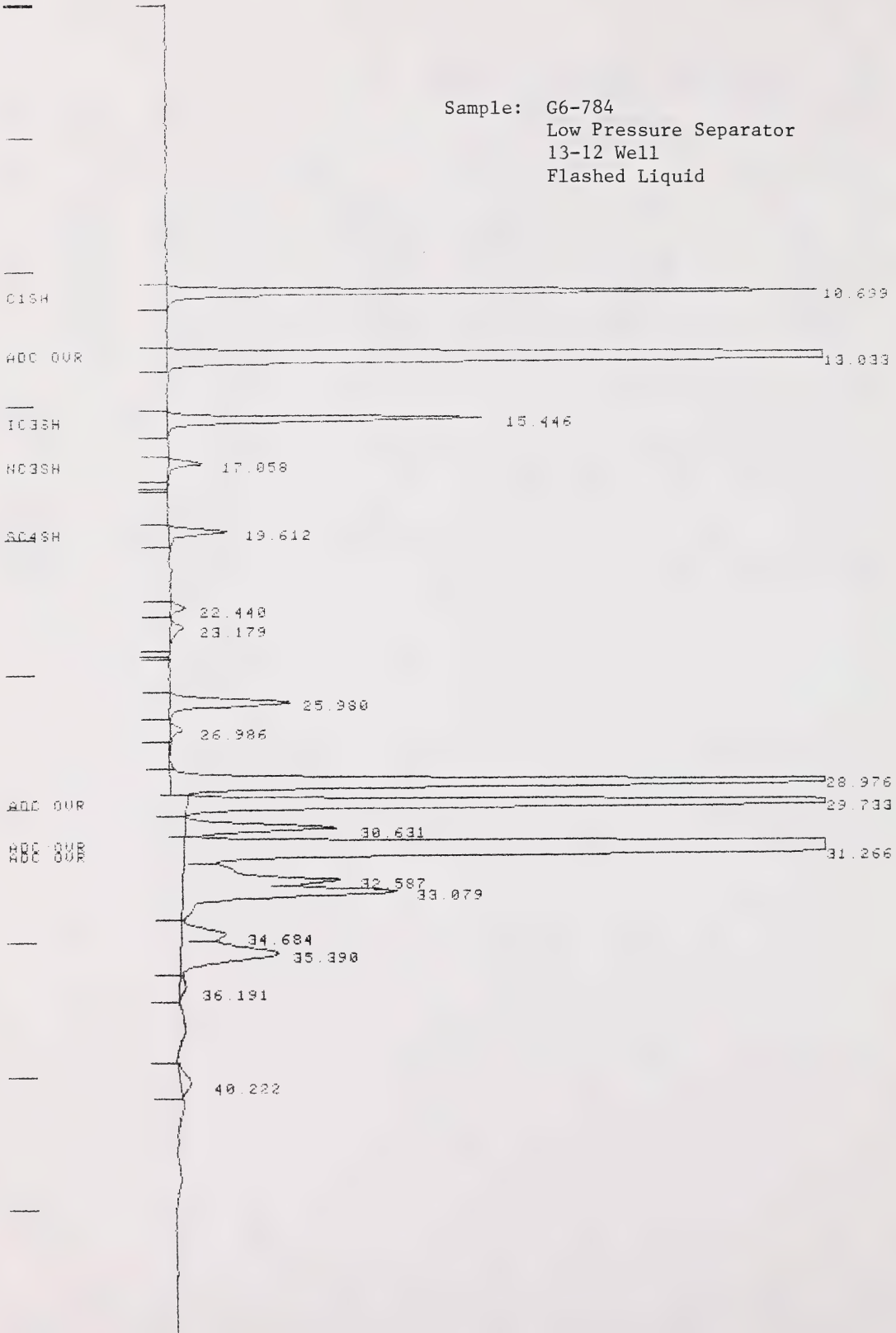
TOTAL UNIDENT AREA/HT: 3189

DETECTED PKS: 17 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 330.3 OFFSET: 38

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK



RECALCULATE ON FILE: GAS088

CHANNEL: 1A - 1 TITLE: LODGEPOLE 16:18 23 DEC 87

SAMPLE: GB-784 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
1	C1SH	71.9858	10.699	-0.001	676	BB	10.94
2	C2SH	102.4863	13.033	0.033	1057	BB	? 14.19
3	IC3SH	52.6886	15.446	0.046	471	BB	11.88
4	NC3SH	24.0964	17.058	0.058	154	BB	13.75
5	SC4SH	31.3552	19.612	0.012	203	BB	12.75
TOTALS:		282.5923		0.148	2581		

TOTAL UNIDENT AREA/HT: 5135

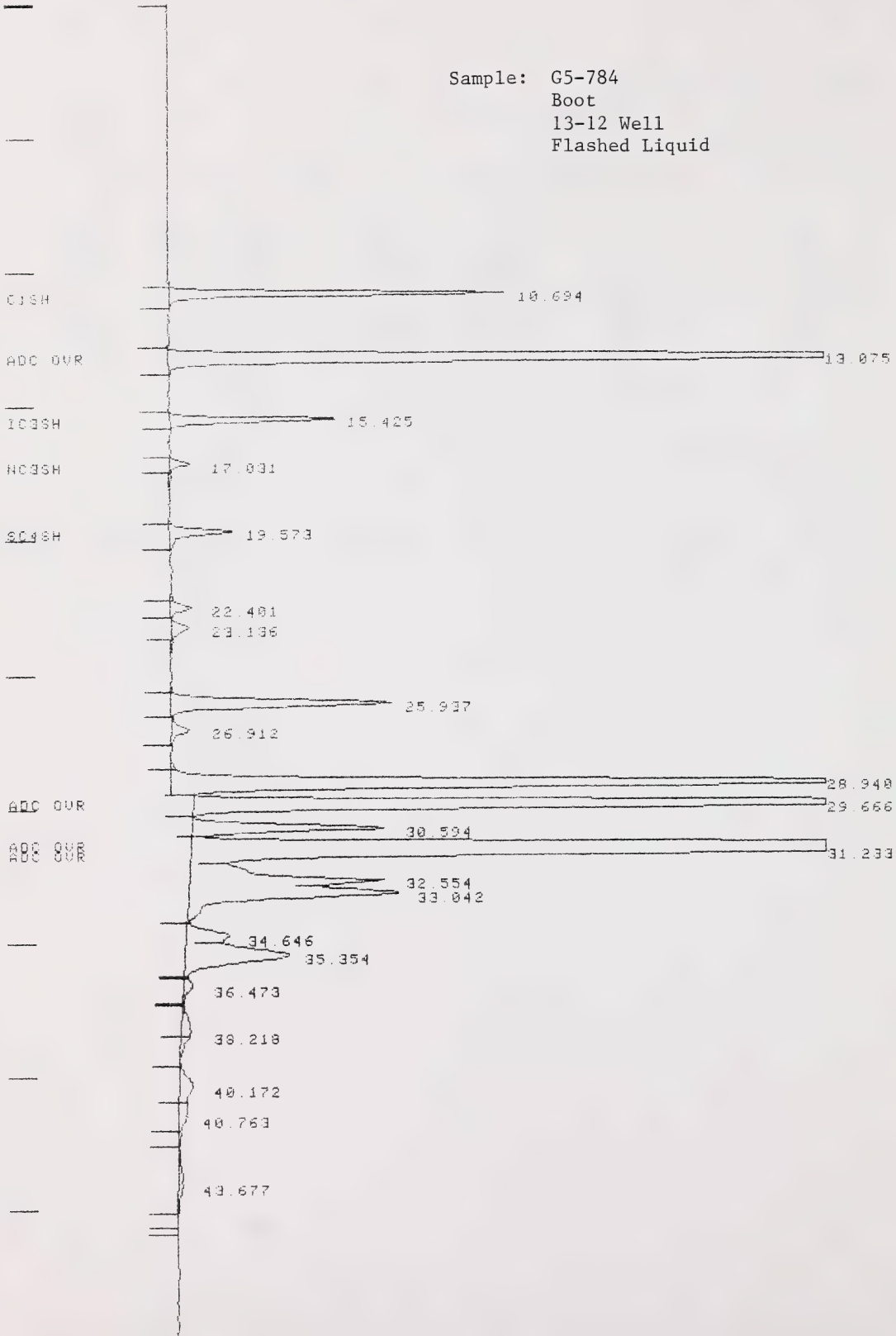
DETECTED PKS: 19 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 330.3 OFFSET: 198

ERRORS:
  ADC OVERANGE

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK



RECALCULATE ON FILE: GAS093

CHANNEL: 1A - 1 TITLE: LODGEPOLE 9:32 24 DEC 87

SAMPLE: 86-784 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	53.3136	10.694	-0.006	485	BB		10.88
2	C2SH	102.5591	13.075	0.075	1058	BB	?	13.13
3	IC3SH	39.7182	15.425	0.025	347	BB		12.00
4	NC3SH	19.1717	17.031	0.031	117	BB		14.31
5	SC4SH	32.3309	19.573	-0.027	212	BB		12.50
TOTALS:		247.0934		0.098	2219			

TOTAL UNIDENT AREA/HT: 5645

DETECTED PKS: 22 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 330.3 OFFSET: 470

ERRORS:
ADC OVERANGE

SINGLE CHANNEL METHOD: TCEP-2

SECTION 1: GENERAL
PAGE 1
ANALYSIS PARAMETERS
CHANNEL: 1A
DETECTOR: 1
CALCULATION: ES
HT/AREA: S
STOP TIME: 20.00
NUMB EXPECTED PKS: 40
EQUILIBRATION TIME: 0
UNRETAINED PK TIME: 0.00
SLICE WIDTH: 10

COS Analyses
TCEP - Deactigel Columns
1984 Condensate Samples
Flashed Gas Fractions

PAGE 2
SAMPLE PARAMETERS
RUN TYPE: A
SAMPLE ID:
DIVISOR: 1.000000
AMT STD: 1.000000
MLTPLR: 1.000000

PAGE 3
REPORT INSTRUCTIONS
WHERE TO REPORT: P1
COPIES: 1
TITLE: LODGEPOLE
FORMAT: E
DECIMAL PLACE: 4
RESULT UNITS:
REPORT UNIDENT PKS: N
REPORT INSTRUMENT CONDITIONS: N

PAGE 4
PLOT INSTRUCTIONS
PLOT: Y
REPLOT WITH BASELINES: N
RAW DATA LOCATION: F
ZERO OFFSET: 10
ANNOTATION
RETENTION TIME: Y
PLOT CONTROL: Y
TIME TICKS: Y
TIME EVENTS: N
PK START/END: Y

PAGE 5
CHART SPEED
PAGES OR CM/MIN: C
INIT VALUE: 0.5

PAGE 6
PLOT ATTEN
INIT PLOT ATTEN: 512

SINGLE CHANNEL METHOD: TCEP-2

SECTION 2: TIME EVENTS
PAGE 1

LINE#	TIME	EVENT	VALUE
1	0.00	PR	50
2	0.00	SN	4
3	0.00	T%	5.0
4	0.00	WI	4.0

SECTION 3: PEAK TABLE
PAGE 1

STD PK#: 0
RELATIVE RETEN PK#: 0
RESOLUTION PK#: 0
RESOLUTION MINIMUM: 0.0
TOL%: 5.0
IDENTIFICATION TIME WINDOWS +/-
REF
%: 10
MIN: 0.00
NON REF
%: 5
MIN: 0.00
CALIBRATION CURVE: LN
NUMBER CALIB LEVELS: 5
NUMBER INJ/LEVEL: 2
UNIDENT PK FACTOR: 0.000E+00

PAGE 2

PK#	TIME	NAME	AMOUNT	R	GR	COEF0	COEF1	COEF2	COEF3
1	7.600	*COS	284.77			1.189E+05	3.867E+03	0.000E+00	0.000E+00

SINGLE CHANNEL METHOD: TCEP-2

SECTION 4: GC INSTRUMENT CONTROL

PAGE 1

COL TEMP

ISO/INIT COL TEMP: 40

INIT HOLD TIME: 5.00

STEP#	FINAL TEMP	RATE	HOLD TIME
1	80	10.0	10.00

PAGE 2

DETECTORS

DET A TYPE: FPD

DET B TYPE: FID

LINE#	TIME	SIDE	ATTN	RANGE	ZERO
1	0.00	A	16	9	Y
2	0.00	B	512	12	Y

PAGE 3

TEMP/FLOW

INJ A TEMP: 210

INJ B TEMP: 60

ION TEMP: 220

TCD TEMP:

TCD FIL TEMP:

AUX TEMP:

COL A FLOW: 30

COL B FLOW: 30

PAGE 4

LINE#	TIME	RELAY ON	RELAY OFF
1	0.00	2	1
2	0.01	1	
3	4.00		2

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK

Sample: P1-684
High Pressure Separator
10-2 Well
Flashed Gas

RECALCULATE ON FILE: CARBONYL033

CHANNEL: 1A - 1 TITLE: LODGEPOLE 15:39 11 JAN 88

SAMPLE: P1-684 METHOD: TCEP-2 CALCULATION: ES - ANALYS - LN

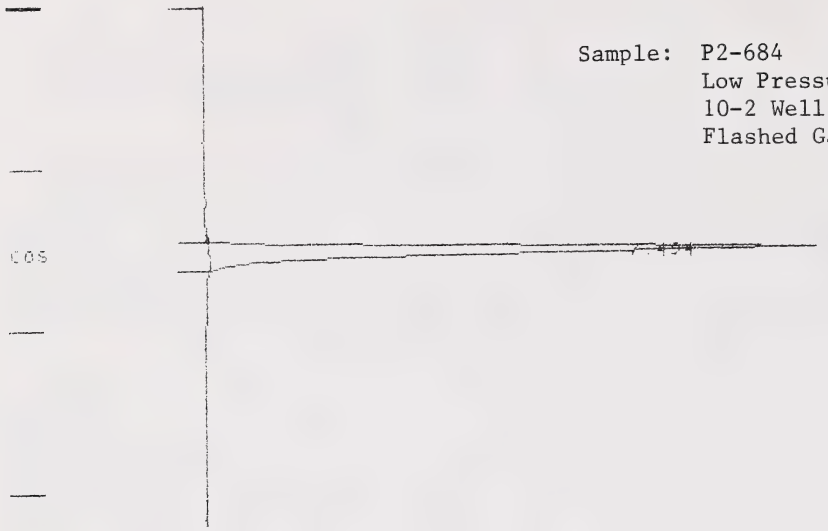
PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
1	COS	170.4370	8.061	0.061	410	BB	13.25
TOTALS:		170.4370		0.061	410		

DETECTED PKS: 1 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 400.0 OFFSET: 9

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK



Sample: P2-684
Low Pressure Separator
10-2 Well
Flashed Gas

RECALCULATE ON FILE: CARBONYL043

CHANNEL: 1A - 1 TITLE: LODGEPOLE 11:24 12 JAN 88

SAMPLE: P2-684 METHOD: TCEP-2 CALCULATION: ES - ANALYS - LN

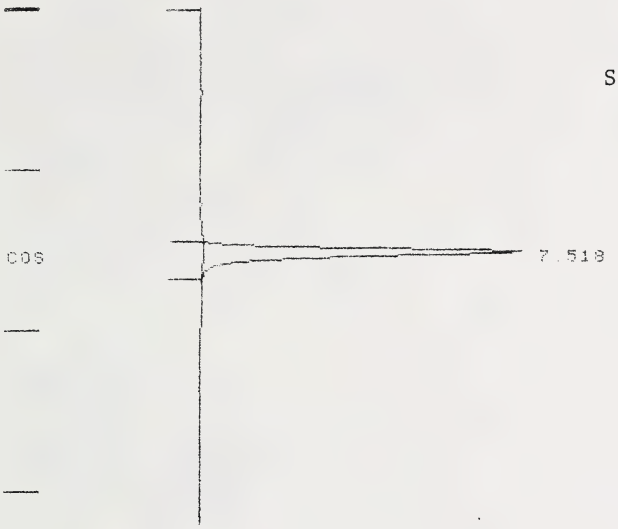
PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
1	COS	241.9765	7.494	-0.106	595	BB ?	15.06
TOTALS:		241.9765		-0.106	595		

DETECTED PKS: 1 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 400.0 OFFSET: -6

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK



Sample: G4-784
High Pressure Separator
13-12 Well
Flashed Gas

RECALCULATE ON FILE: CARBONYL048

CHANNEL: 1A - 1 TITLE: LODGEPOLE 14:25 12 JAN 88

SAMPLE: G4-784 METHOD: TCEP-2 CALCULATION: ES - ANALYS - LN

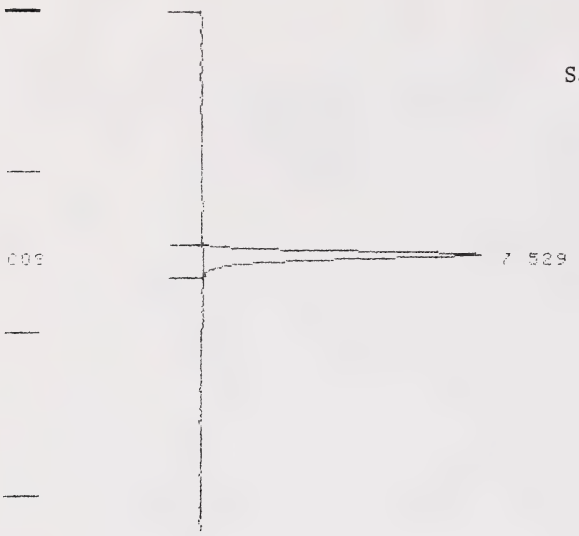
PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
1	COS	178.9444	7.518	-0.082	432	BB	14.75
TOTALS:		178.9444		-0.082	432		

DETECTED PKS: 1 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 400.0 OFFSET: 151

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK



Sample: G6-784
Low Pressure Separator
13-12 Well
Flashed Gas

RECALCULATE ON FILE: CARBONYL059

CHANNEL: 1A - 1 TITLE: LODGEPOLE 11:18 13 JAN 88

SAMPLE: G6-784 METHOD: TCEP-2 CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
1	COS	168.8902	7.529	-0.071	406	BB	14.81
TOTALS:		168.8902		-0.071	406		

DETECTED PKS: 1 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 400.0 OFFSET: -12

SINGLE CHANNEL METHOD: RECALC

SECTION 1: GENERAL
PAGE 1
ANALYSIS PARAMETERS
CHANNEL: 1A
DETECTOR: 1
CALCULATION: ES
HT/AREA: S
STOP TIME: 32.50
NUMB EXPECTED PKS: 40
EQUILIBRATION TIME: 0
UNRETAINED PK TIME: 0.00
SLICE WIDTH: 10

PAGE 2
SAMPLE PARAMETERS
RUN TYPE: A
SAMPLE ID: LODGEPOLE
DIVISOR: 1.000000
AMT STD: 1.000000
MLTPLR: 1.000000

PAGE 3
REPORT INSTRUCTIONS
WHERE TO REPORT: P1
COPIES: 1
TITLE: LODGEPOLE
FORMAT: E
DECIMAL PLACE: 4
RESULT UNITS:
REPORT UNIDENT PKS: N
REPORT INSTRUMENT CONDITIONS: N

PAGE 4
PLOT INSTRUCTIONS
PLOT: Y
REPLOT WITH BASELINES: N
RAW DATA LOCATION: F
ZERO OFFSET: 10
ANNOTATION
RETENTION TIME: Y
PLOT CONTROL: Y
TIME TICKS: Y
TIME EVENTS: N
PK START/END: Y

PAGE 5
CHART SPEED
PAGES OR CM/MIN: C
INIT VALUE: 0.5

PAGE 6
PLOT ATTEN
INIT PLOT ATTEN: 128

Mercaptan & CS_2 Analyses
Porapak - Porapak Columns
1987 13-12 Well Samples
Well Head Separator

SINGLE CHANNEL METHOD: RECALC

SECTION 2: TIME EVENTS
PAGE 1

LINE#	TIME	EVENT	VALUE
1	0.00	PR	30
2	0.00	SN	4
3	0.00	T%	100.0
4	0.00	WI	4.0
5	0.00	II	4.50

SECTION 3: PEAK TABLE
PAGE 1

STD PK#: 0
RELATIVE RETEN PK#: 0
RESOLUTION PK#: 0
RESOLUTION MINIMUM: 0.0
TOL%: 5.0
IDENTIFICATION TIME WINDOWS +/-
REF
%: 10
MIN: 0.10
NON REF
%: 5
MIN: 0.10
CALIBRATION CURVE: LN
NUMBER CALIB LEVELS: 4
NUMBER INJ/LEVEL: 2
UNIDENT PK FACTOR: 0.000E+00

PAGE 2

PK#	TIME	NAME	AMOUNT	R	GR	COEF0	COEF1	COEF2	COEF3
1	10.500	*C1SH	105.30			5.900E+04	9.776E+02	0.000E+00	0.000E+00
2	13.000	*C2SH	94.950			4.419E+04	9.276E+02	0.000E+00	0.000E+00
3	15.400	*IC3SH	83.990			3.422E+04	1.046E+03	0.000E+00	0.000E+00
4	17.000	*NC3SH	53.250			3.599E+04	1.331E+03	0.000E+00	0.000E+00
5	19.600	*SC4SH	118.25			9.350E+04	1.084E+03	0.000E+00	0.000E+00
6	21.010	*NC4SH	21.950			5.375E+03	1.009E+03	0.000E+00	0.000E+00

SINGLE CHANNEL METHOD: RECALC

SECTION 4: GC INSTRUMENT CONTROL

PAGE 1

COL TEMP

ISO/INIT COL TEMP: 90

INIT HOLD TIME: 8.00

STEP#	FINAL TEMP	RATE	HOLD TIME
1	170	5.0	4.00
2	200	20.0	3.00

PAGE 2

DETECTORS

DET A TYPE: FPD

DET B TYPE: FID

LINE#	TIME	SIDE	ATTN	RANGE	ZERO
1	0.00	A	16	10	Y
2	0.00	B	128	12	Y

PAGE 3

TEMP/FLOW

INJ A TEMP: 210

INJ B TEMP: 60

ION TEMP: 220

TCD TEMP:

TCD FIL TEMP:

AUX TEMP:

COL A FLOW: 30

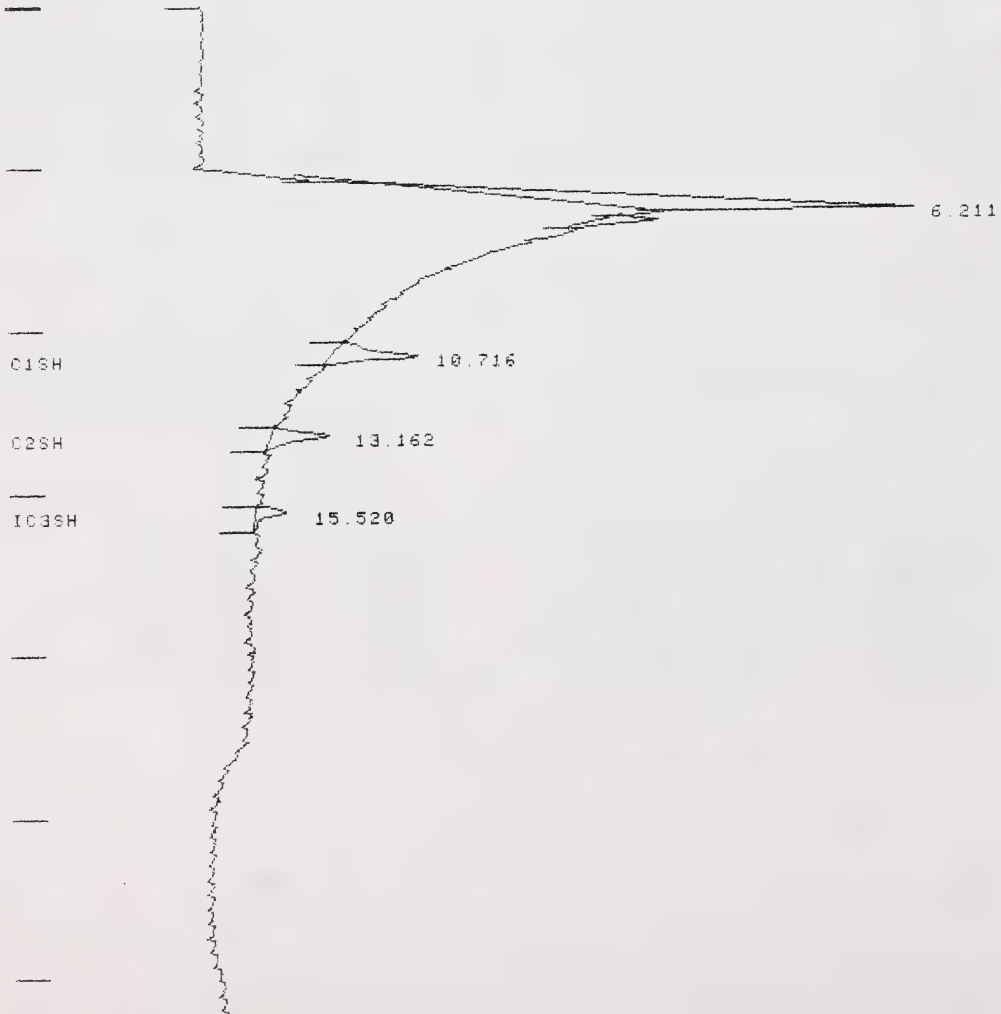
COL B FLOW: 30

PAGE 4

LINE#	TIME	RELAY ON	RELAY OFF
1	0.00		12
2	0.01	1	
3	4.00	2	
4	22.00		2

Sample: G1-1087
Gas Sample
6 Hours

CHART SPEED 0.5 CM/MIN
ATTEN: 128 ZERO: 10% 5 MIN/TICK



RECALCULATE ON FILE: GAS073

CHANNEL: 1A - 1 TITLE: LODGEPOLE 17:37 30 OCT 87

SAMPLE: G1-1087 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
1	C1SH	17.0446	10.716	0.216	114	BB	13.88
2	C2SH	12.8602	13.162	0.162	91	BB	14.44
3	IC3SH	10.2210	15.520	0.120	65	BB	14.25
TOTALS:		40.1258		0.498	270		

TOTAL UNIDENT AREA/HT: 302

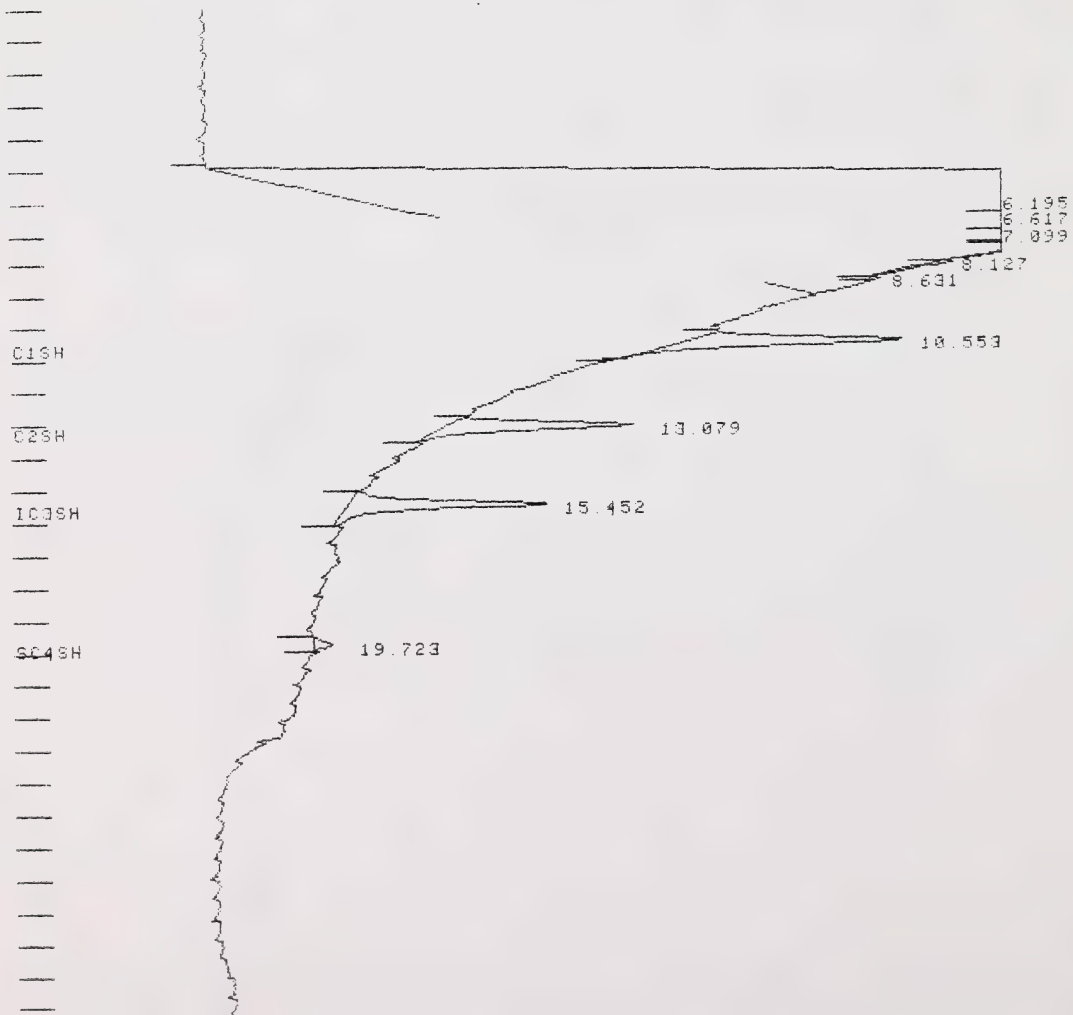
DETECTED PKS: 5 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 330.3 OFFSET: -361

Sample: G1-1087
Gas Sample
7 Months

CHART SPEED: 0.5 CM/MIN
ATTEN: 128 ZERO: 10% 1 MIN/TICK



RECALCULATE ON FILE: LOOG087

CHANNEL: 1A - 1 TITLE: LOOSEPOLE 11:24 16 MAY 88

SAMPLE: G1-1087 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	23.4968	10.553	-0.047	180	VD	?	
2	C2SH	19.7244	13.079	0.079	165	BB		13.69
3	IC3SH	21.4132	15.452	0.052	172	BB		15.25
4	SC4SH	14.7700	19.723	0.123	50	VD	?	
TOTALS:		79.4044		0.207	567			

TOTAL UNIDENT AREA/HT: 929

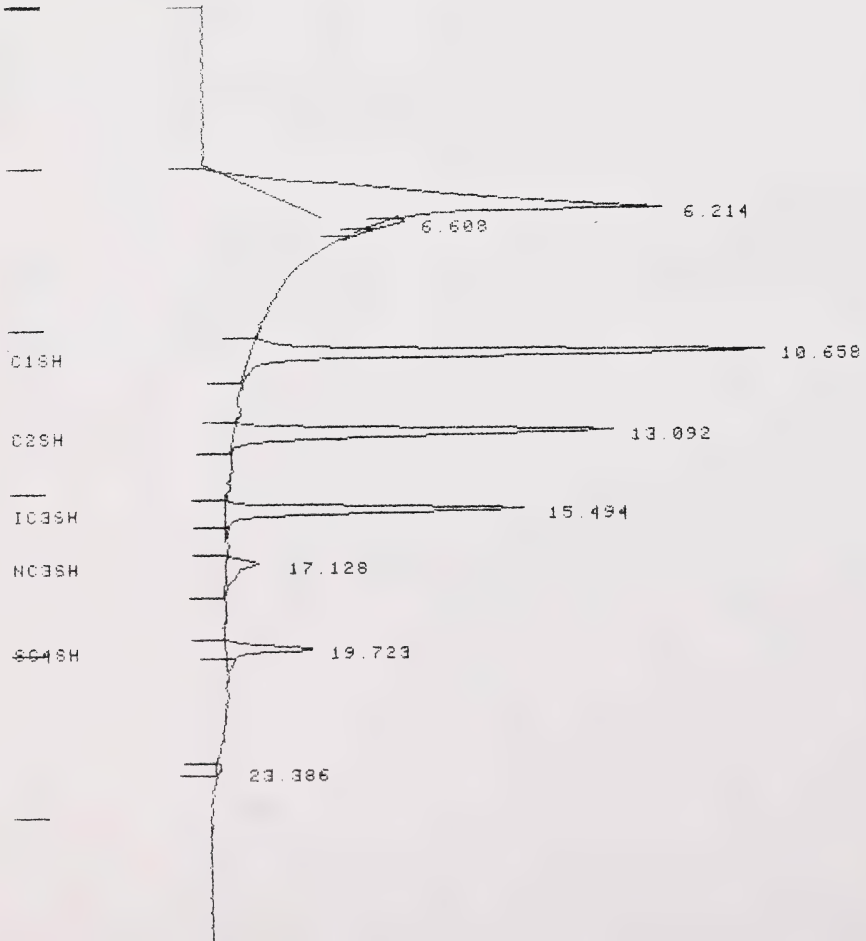
DETECTED PKS: 10 REJECTED PKS: 1

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 268.6 OFFSET: 10

Sample: P5-1087
Condensate Sample
Flashed Gas Fraction
6 Hours

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK



RECALCULATE ON FILE: GAS075

CHANNEL: 1A - 1 TITLE: LODGEPOLE 19:01 30 OCT 87

SAMPLE: P5-1057 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
1	C1SH	59.2770	10.658	0.058	545	BB	12.59
2	C2SH	47.9234	13.092	0.092	469	BB	14.19
3	IC3SH	46.9356	15.494	0.094	416	BB	12.75
4	NC3SH	21.8337	17.128	0.128	137	BB	18.19
5	SO4SH	33.7400	19.723	0.123	225	BB	14.00
TOTALS:		209.7097		0.495	1793		

TOTAL UNIDENT AREA/HT: 602

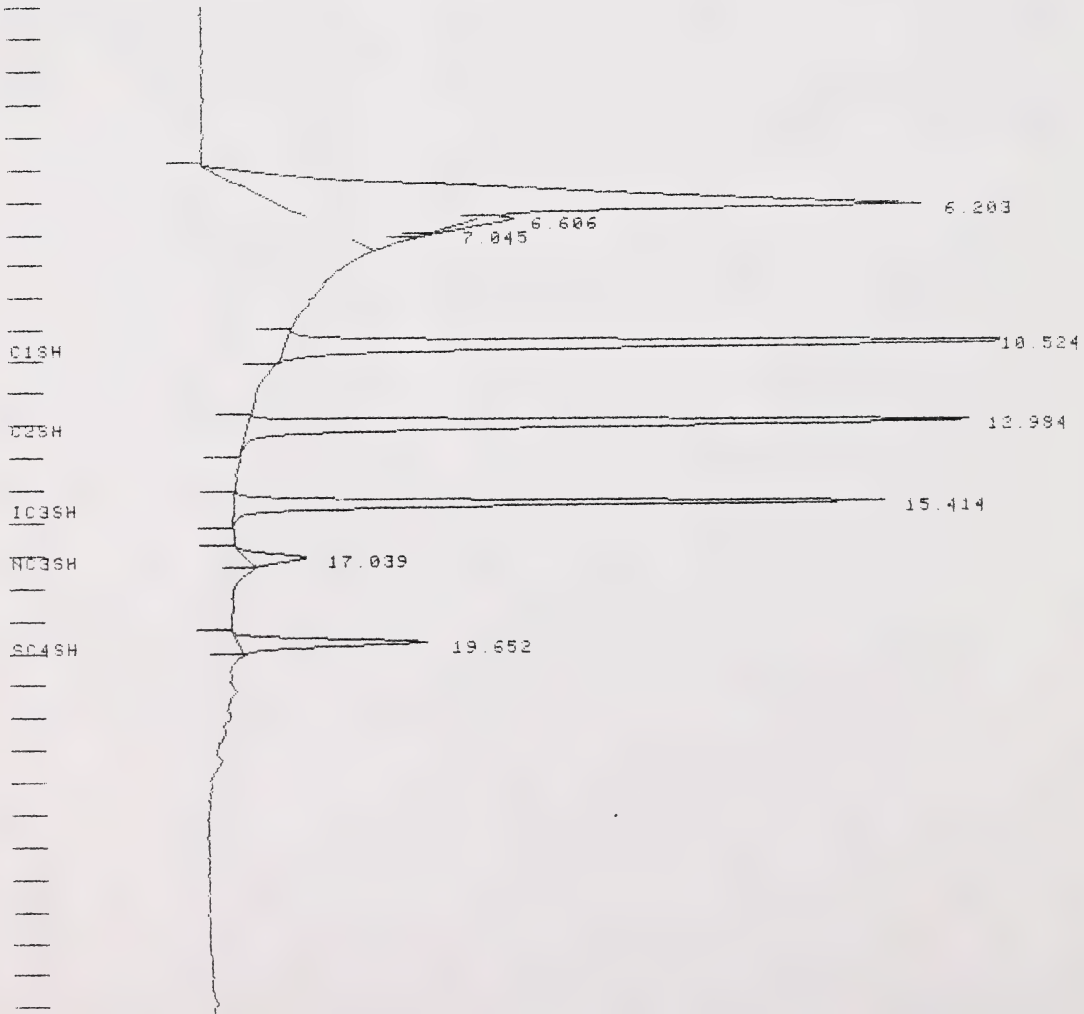
DETECTED PKS: 8 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 330.3 OFFSET: 276

Sample: P5-1087
Condensate Sample
Flashed Gas Fraction
7 Months

CHART SPEED: 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 1 MIN/TICK



RECALCULATE ON FILE: LODG091

CHANNEL: 1A - 1 TITLE: LODGEPOLE 10:02 18 MAY 88

SAMPLE: P5-1087 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	C1SH	74.8208	10.524	-0.076	705	UD	?	
2	C2SH	64.9913	12.984	-0.016	653	BB		13.69
3	IC3SH	67.7510	15.414	0.014	615	BB		12.31
4	NC3SH	28.3556	17.039	0.039	186	UD	?	
5	SC4SH	45.2304	19.652	0.052	331	UD	?	
TOTALS:		281.1491		0.013	2490			

TOTAL UNIDENT AREA/HT: 755

DETECTED PKS: 8 REJECTED PKS: 1

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 356.6 OFFSET: 100

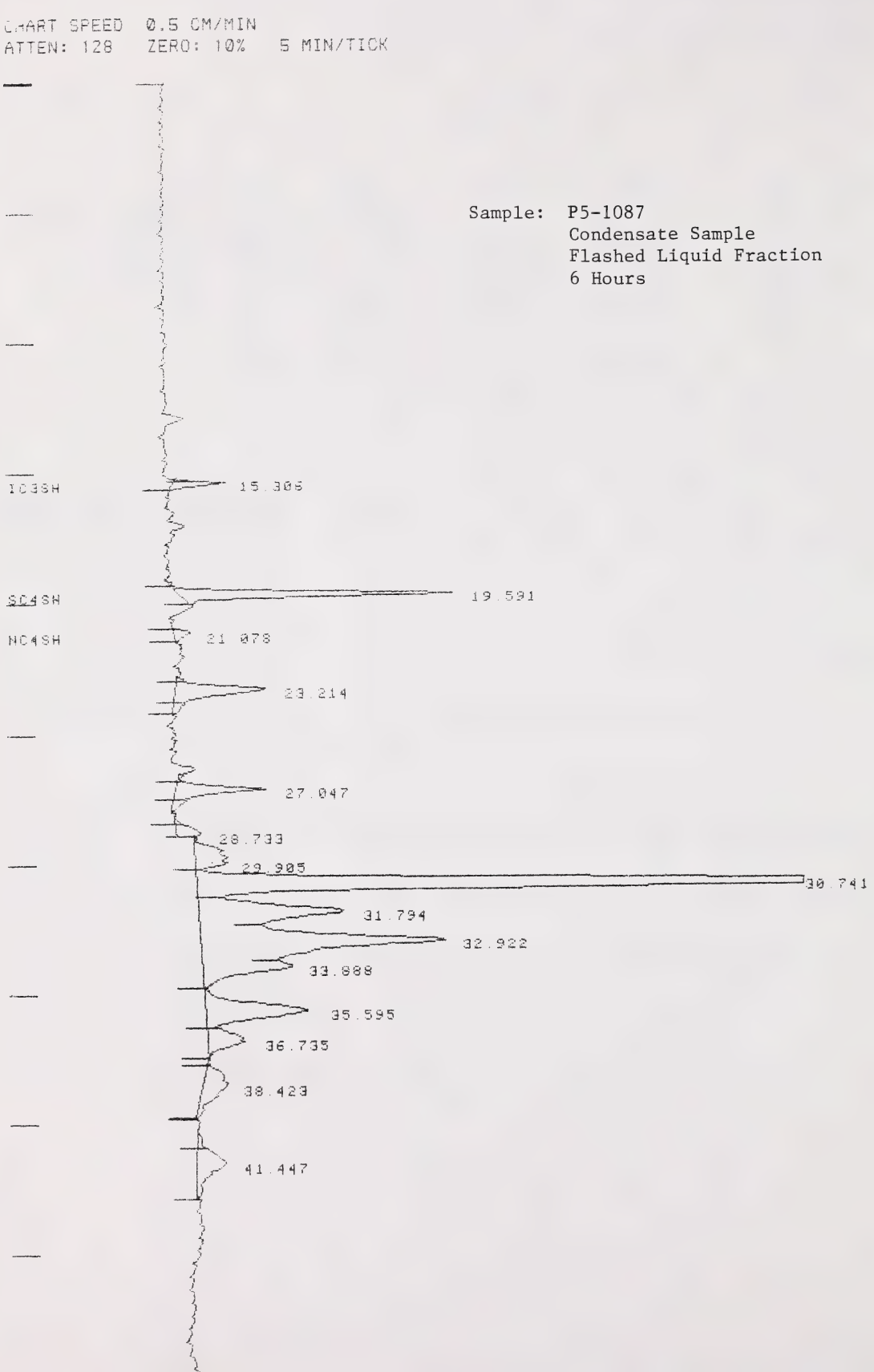


CHART SPEED 0.5 CM/MIN
ATTEN: 128 ZERO: 10% 5 MIN/TICK
Sample: P5-1087
Condensate Sample
Flashed Liquid Fraction
6 Hours
IC3SH
SC4SH
NC4SH
15.306
19.591
21.078
23.214
27.047
28.733
29.905
30.741
31.794
32.922
33.888
35.595
36.735
38.423
41.447

RECALCULATE ON FILE: GAS077

CHANNEL: 1A - 1 TITLE: LODGEPOLE 20:18 30 OCT 87

SAMPLE: P5-1037 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE		W1/2 (SEC)
1	IC3SH	13.4636	15.306	-0.094	96	BB	?	9.25
2	SO4SH	33.4148	19.591	-0.009	222	BB		12.56
3	NO4SH	5.9861	21.078	0.068	54	BB	?	12.50
TOTALS:		52.8645		-0.035	372			

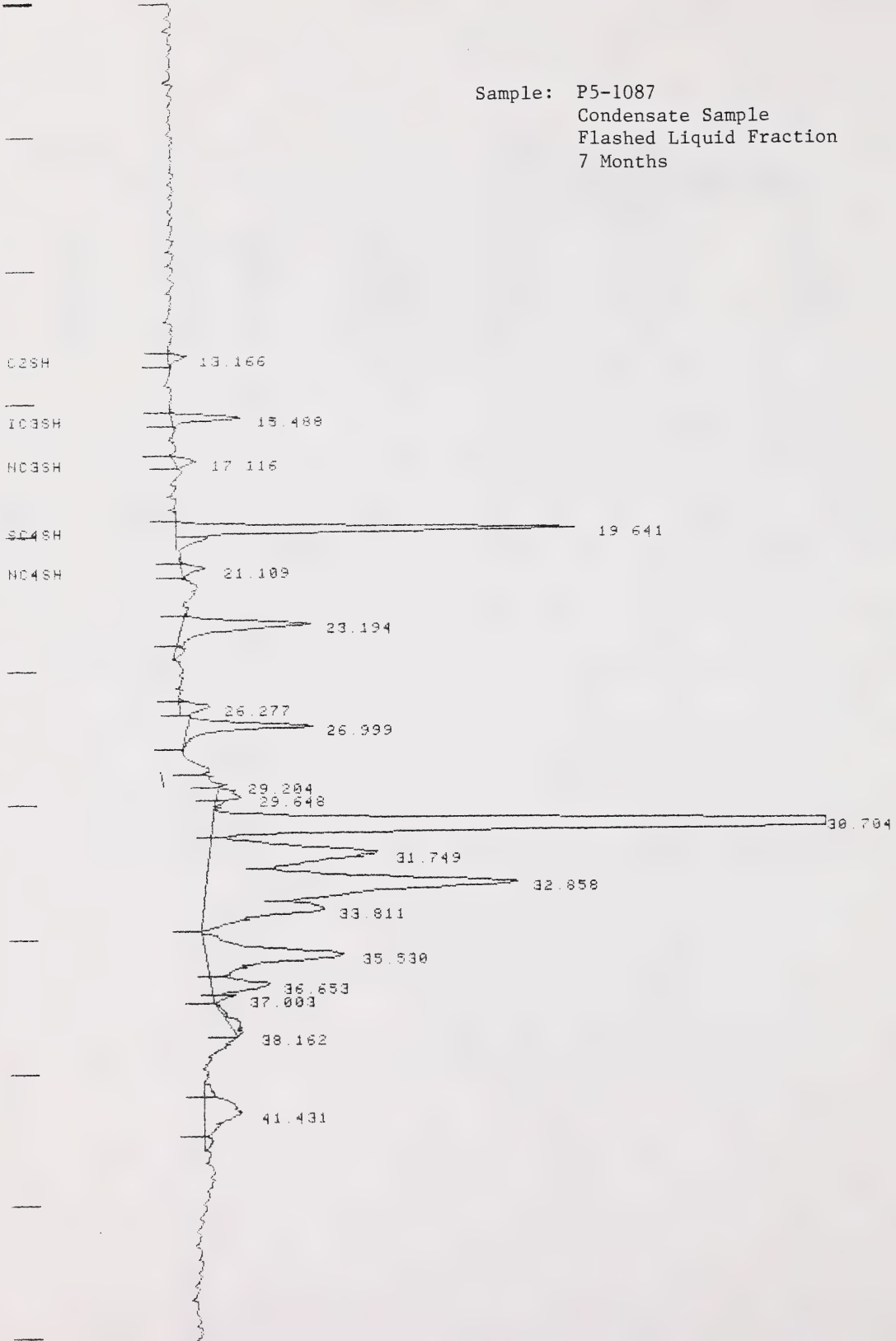
TOTAL UNIDENT AREA/HT: 1660

DETECTED PKS: 15 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 330.3 OFFSET: 61

CHART SPEED 0.5 CM/MIN
ATTEN: 128 ZERO: 10% 5 MIN/TICK



RECALCULATE ON FILE: GAS076

CHANNEL: 1A - 1 TITLE: LODGEPOLE 13:08 18 MAY 88

SAMPLE: P5-1087 METHOD: RECALC CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
1	C2SH	9.7063	13.166	0.166	57	BB	11.50
2	IC3SH	15.0326	15.488	0.088	111	BB	12.25
3	NC3SH	12.1174	17.116	0.116	64	BB	18.94
4	SC4SH	38.1844	19.641	0.041	266	BB	12.31
5	NC4SH	6.9951	21.109	0.099	64	BB	14.50
TOTALS:		82.0358		0.510	562		

TOTAL UNIDENT AREA/HT: 1990

DETECTED PKS: 19 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 330.3 OFFSET: 198

SINGLE CHANNEL METHOD: TCEP

SECTION 1: GENERAL
PAGE 1
ANALYSIS PARAMETERS
CHANNEL: 1A
DETECTOR: 1
CALCULATION: ES
HT/AREA: S
STOP TIME: 16.00
NUMB EXPECTED PKS: 40
EQUILIBRATION TIME: 0
UNRETAINED PK TIME: 0.00
SLICE WIDTH: 10

PAGE 2
SAMPLE PARAMETERS
RUN TYPE: A
SAMPLE ID:
DIVISOR: 1.000000
AMT STD: 1.000000
MLTPLR: 1.000000

PAGE 3
REPORT INSTRUCTIONS
WHERE TO REPORT: P1
COPIES: 1
TITLE: LODGEPOLE
FORMAT: E
DECIMAL PLACE: 4
RESULT UNITS:
REPORT UNIDENT PKS: N
REPORT INSTRUMENT CONDITIONS: N

PAGE 4
PLOT INSTRUCTIONS
PLOT: Y
REPLOT WITH BASELINES: N
RAW DATA LOCATION: F
ZERO OFFSET: 10
ANNOTATION
RETENTION TIME: Y
PLOT CONTROL: Y
TIME TICKS: Y
TIME EVENTS: N
PK START/END: Y

PAGE 5
CHART SPEED
PAGES OR CM/MIN: C
INIT VALUE: 0.5

PAGE 6
PLOT ATTEN
INIT PLOT ATTEN: 256

COS Analyses
TCEP - Deactigel Columns
1987 13-12 Well Samples
Well Head Separator
Gas Sample G1-1087

SINGLE CHANNEL METHOD: TCEP

SECTION 2: TIME EVENTS
PAGE 1

LINE#	TIME	EVENT	VALUE
1	0.00	PR	50
2	0.00	SN	4
3	0.00	T%	5.0
4	0.00	WI	4.0

SECTION 3: PEAK TABLE
PAGE 1

STD PK#: 0
RELATIVE RETEN PK#: 0
RESOLUTION PK#: 0
RESOLUTION MINIMUM: 0.0
TOL%: 5.0
IDENTIFICATION TIME WINDOWS +/-
REF
%: 10
MIN: 0.00
NON REF
%: 5
MIN: 0.00
CALIBRATION CURVE: OP
NUMBER CALIB LEVELS: 1
NUMBER INJ/LEVEL: 1
UNIDENT PK FACTOR: 0.000E+00

PAGE 2

PK#	TIME	NAME	AMOUNT	R	GR	COEF0	COEF1	COEF2	COEF3
1	7.500	*COS	55.080			0.000E+00	1.496E+03	0.000E+00	0.000E+00

SINGLE CHANNEL METHOD: TCEP

SECTION 4: GC INSTRUMENT CONTROL
PAGE 1

COL TEMP
ISO/INIT COL TEMP: 40
INIT HOLD TIME: 5.00

STEP#	FINAL TEMP	RATE	HOLD TIME
1	90	10.0	10.00

PAGE 2

DETECTORS
DET A TYPE: FPD
DET B TYPE: FID

LINE#	TIME	SIDE	ATTN	RANGE	ZERO
1	0.00	A	16	10	Y
2	0.00	B	512	12	Y

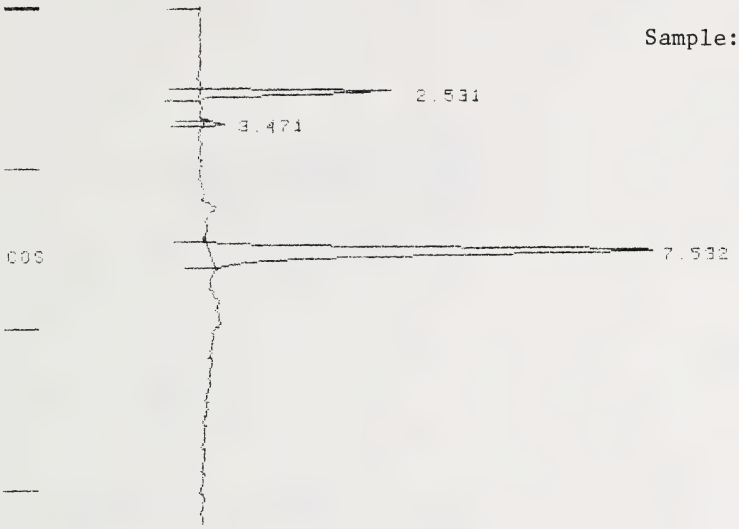
PAGE 3

TEMP/FLOW
INJ A TEMP: 210
INJ B TEMP: 60
ION TEMP: 220
TCD TEMP:
TCD FIL TEMP:
AUX TEMP:
COL A FLOW: 30
COL B FLOW: 30

PAGE 4

LINE#	TIME	RELAY ON	RELAY OFF
1	0.00	2	1
2	0.01	1	
3	4.00		2

CHART SPEED 0.5 CM/MIN
ATTEN: 256 ZERO: 10% 5 MIN/TICK



Sample: G1-1087
Gas Sample

RECALCULATE ON FILE: CARBONYL034

CHANNEL: 1A - 1 TITLE: LODGEPOLE 11:00 5 NOV 87

SAMPLE: G1-1087 METHOD: TCEP CALCULATION: ES - ANALYS - OP

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
1	COS	54.4544	7.532	0.032	364	BB	14.69
TOTALS:		54.4544		0.032	364		

TOTAL UNIDENT AREA/HT: 366

DETECTED PKS: 3 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 400.0 OFFSET: -83

```
    SINGLE   CHANNEL METHOD: TCEP-2


    SECTION 1: GENERAL
    PAGE 1
ANALYSIS PARAMETERS
CHANNEL: 1A
DETECTOR: 1
CALCULATION: ES
HT/AREA: S
STOP TIME:  16.00
NUMB EXPECTED PKS:   40
EQUILIBRATION TIME:  0
UNRETAINED PK TIME:   0.00
SLICE WIDTH:  10

    PAGE 2
SAMPLE PARAMETERS
RUN TYPE: A
SAMPLE ID:
DIVISOR: 1.000000
AMT STD: 1.000000
MLTPLR: 1.000000

    PAGE 3
REPORT INSTRUCTIONS
WHERE TO REPORT: P1
COPIES:   1
TITLE: LODGEPOLE
FORMAT: E
DECIMAL PLACE: 4
RESULT UNITS:
REPORT UNIDENT PKS: N
REPORT INSTRUMENT CONDITIONS: N

    PAGE 4
PLOT INSTRUCTIONS
PLOT: Y
REPLOT WITH BASELINES: N
  RAW DATA LOCATION: F
ZERO OFFSET: 10
ANNOTATION
  RETENTION TIME: Y
  PLOT CONTROL: Y
  TIME TICKS: Y
  TIME EVENTS: N
  PK START/END: Y

    PAGE 5
CHART SPEED
  PAGES OR CM/MIN: C
  INIT VALUE:  0.5

    PAGE 6
PLOT ATTEN
INIT PLOT ATTEN: 512
```

COS Analyses
TCEP - Deactigel Columns
1987 13-12 Well Samples
Well Head Separator
Condensate Sample P5-1087

SINGLE CHANNEL METHOD: TCEP-2

SECTION 2: TIME EVENTS
PAGE 1

LINE#	TIME	EVENT	VALUE
1	0.00	PR	50
2	0.00	SN	4
3	0.00	T%	5.0
4	0.00	WI	4.0

SECTION 3: PEAK TABLE
PAGE 1

STD PK#: 0
RELATIVE RETEN PK#: 0
RESOLUTION PK#: 0
RESOLUTION MINIMUM: 0.0
TOL%: 5.0
IDENTIFICATION TIME WINDOWS +/-
REF
%: 10
MIN: 0.00
NON REF
%: 5
MIN: 0.00
CALIBRATION CURVE: LN
NUMBER CALIB LEVELS: 5
NUMBER INJ/LEVEL: 2
UNIDENT PK FACTOR: 0.000E+00

PAGE 2

PK#	TIME	NAME	AMOUNT	R	GR	COEF0	COEF1	COEF2	COEF3
1	7.600	*COS	284.77			1.189E+05	3.867E+03	0.000E+00	0.000E+00

SINGLE CHANNEL METHOD: TCEP-2

SECTION 4: GC INSTRUMENT CONTROL
PAGE 1
COL TEMP
ISO/INIT COL TEMP: 40
INIT HOLD TIME: 5.00

STEP#	FINAL TEMP	RATE	HOLD TIME
1	80	10.0	10.00

PAGE 2
DETECTORS
DET A TYPE: FPD
DET B TYPE: FID

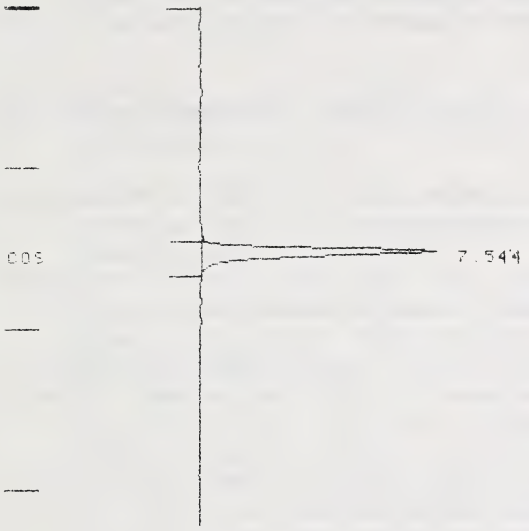
LINE#	TIME	SIDE	ATTN	RANGE	ZERO
1	0.00	A	16	9	Y
2	0.00	B	512	12	Y

PAGE 3
TEMP/FLOW
INJ A TEMP: 210
INJ B TEMP: 60
ION TEMP: 220
TCD TEMP:
TCD FIL TEMP:
AUX TEMP:
COL A FLOW: 30
COL B FLOW: 30

PAGE 4

LINE#	TIME	RELAY ON	RELAY OFF
1	0.00	2	1
2	0.01	1	
3	4.00		2

CHART SPEED 0.5 CM/MIN
ATTEN: 512 ZERO: 10% 5 MIN/TICK



Sample: P5-1087
Condensate Sample
Flashed Gas Fraction

RECALCULATE ON FILE: CARBONYL039

CHANNEL: 1A - 1 TITLE: LODGEPOLE 14:12 5 NOV 87

SAMPLE: P5-1087 METHOD: TCEP-2 CALCULATION: ES - ANALYS - LN

PEAK NO	PEAK NAME	RESULT	TIME (MIN)	TIME OFFSET	HEIGHT COUNTS	SEP CODE	W1/2 (SEC)
1	COS	155.3557	7.544	-0.056	371	BB	14.75
TOTALS:		155.3557		-0.056	371		

DETECTED PKS: 1 REJECTED PKS: 0

DIVISOR: 1.00000 AMT STD: 1.00000 MULTIPLIER: 1.00000

NOISE: 400.0 OFFSET: 36

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N.L.C. - B.N.C.
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